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## THE NUFFIELD FOUNDATION

THE Nuffield Foundation was established by Lord Nuffield in April 1943 with wide objectives, including the advancement of health and the prevention and relief of sickness, particularly by medical research and teaching and the organization and development of medical and health services; the advancement of social well-being, particularly by scientific research, and the organization, development and improvement of technical and commercial education; the care and comfort of the aged poor; and the advancement of education. These four objectives are sufficiently wide in themselves, but any other charitable purposes may be included in the Foundation's objectives on the written declaration of either Lord Nuffield in his lifetime or, after his death, of the trustees. That provision should sufficiently eliminate the danger of the dead hand, which Lord Nathan's Committee has been investigating since 1950; nor have successive annual reports of the Foundation indicated that there is any danger of the Foundation spreading its resources too thinly over too many objectives.

The principles upon which the Foundation has based the policies which have guided the administration of grants exceeding, in the past ten years, four million pounds, have been clearly indicated from time to time in its annual reports, notably in the fourth and sixth reports, in 1949 and 1951, respectively. Already when Lord Beveridge in 1948 published his report on "Voluntary Action", the work of the Foundation could be cited as an outstanding example of the way in which such independent private ventures could contribute to scientific and social advance, even with greatly increased State support for learning and research. The contribution which voluntary action could make to learning and culture by fostering enterprise and initiative, and ensuring that room for experiment and for testing opinion was maintained, had been fully demonstrated in the work of its first five years.

The tenth birthday of the Foundation was marked by a reception on April 30 at its new headquarters, Nuffield Lodge, Regent's Park, London, N.W., at which Queen Elizabeth the Queen Mother named a room "The Founder's Room" and unveiled a plaque in honour of Lord Nuffield. The first part has also been published of a review of the Foundation's first ten years, in which the main policies pursued are briefly recorded and the kinds of work supported are generally indicated. The grants themselves and, where appropriate, the progress made, are to be described in more detail in a second part, with appendixes, listing published research which the recipients of grants wish to attribute to the Foundation's help, and the names of Foundation fellows, scholars and bursars appointed during the decade. No attempt is made in this first part to distinguish the programmes of the first two five-year periods, though they have differed somewhat in emphasis; nor are the policies of the Foundation here discussed in relation to the current trends of government policy in quite the same way as they

have been, for example, in the third, fourth or sixth annual reports.

Nevertheless, the record is of both public and scientific interest at a time when the place and activities of independent organizations in the promotion of research are being widely discussed both in Great Britain and in the United States of America. As a private fund serving the community, the Foundation has sought to be of service, in part directly, by forwarding projects of possible public benefit; and, in part indirectly, by providing a stimulus to research workers, some of whom might abandon promising but speculative work if there were not known to be resources available to support just this kind of pioneering. Reviewing, for example, the Foundation's support of the physical sciences and its early concern to assist in re-establishing university research in fundamental physics after the War, the review points out that university departments were endangered by the very successes of science and scientists in war-time work.

While most of the fundamental ideas and advances, so rapidly exploited to contribute to victory, had been born in academic departments before the War, there was a tendency to forget or neglect these origins and to attribute the ideas to the environment in which they had only been brought to swift and fruitful maturity. The urgent factor was the danger that the official establishments of government-sponsored applied research might prove too tempting to the brilliant men they had recruited from academic research, and some would be deterred by the prospect of inadequate apparatus and technical assistance from returning to the essential work of advancing knowledge and training research workers.

While not all the fears about the long-term after-effects of war on the standard of academic research proved to be justified, the part which the Foundation was able to play here was significant, and was the more valuable in that it was given quickly at a critical time. The lesson of research conducted under the press of war, that it is possible and worth while to multiply the effective work of a few good men by giving them technical tools and technicians on a scale well beyond that of peace-time, was applied by a private institution with a swiftness and efficacy that no government-controlled establishment could hope to emulate. As the review rightly but modestly remarks, when foundations and trusts accept such proper challenges to pioneer in the public interest, they should be judged not only by the success of this or that particular venture, but also by their general record of adventurousness.

The work here reviewed is in reality the product of less than ten years: the Foundation's first five-year programme dates from 1944. In the medical field, emphasis was laid on normal health rather than specific diseases, especially on child health, industrial health, and dental health, apart from rheumatism, the early study of which brought Capt. Oliver Bird's benefaction of £450,000; and, in physics, on nuclear research. For the second period, to end in 1954, the Foundation expressed a preference for assisting biological and sociological studies, and a willingness to begin to consider grants for research overseas; but a further desire to bring scientists and others together in research on practical problems has met with few opportunities. Grants for the welfare of old people and for research into their needs have continued through both periods, totalling £925,000, since 1947 chiefly through the National Corporation for the Care of Old People. The policy of awarding fellowships and similar personal help for training and travel has also continued over the whole period, accounting for a further £831,000, though the schemes have been varied from time to time to serve different purposes or opportunities. Grants for medical work totalled £786,000, including £229,000 for rheumatism; £347,000 for biological research; £560,000 for research in physics; £463,000 for projects in the social sciences; while research specifically related to agriculture received £32,000.

Such figures attest the scale and range of the Foundation's activities, rather than its pioneering character. That, however, is amply revealed in the sections which review in fuller detail the Foundation's policy in particular fields. In the medical sciences, for example, in accordance with a general policy of establishing and encouraging the study of child health, industrial health and dental health as academic subjects pursued at the highest level of academic work, and linked, where appropriate, to the conditions of the surrounding community, it has granted £100,000 towards the establishment in the University of London of a worthy institute of child health, and has assisted in making the study of health as it is affected by work and working conditions a subject of research in the Universities of Durham, Glasgow and Manchester. In rheumatism, besides encouraging fundamental work into causes and scientifically controlled trials of existing therapy, the Foundation has since 1949 supported much chemical work on the total synthesis of cortisone and the production of analogous substances with similar but less harmful effects.

In the biological sciences, where grants have on the whole been numerous and small, rather than, as in physics, few and large, the pioneer character of the programme is specially pronounced, the aim being to encourage work on the normal mechanisms of growth, differentiation and self-maintenance of living things. The early emphasis on nuclear research in physics has already been noted: besides this, the Foundation has sought to foster work on promising new techniques and tools of physics of value not only there but also in the investigation of biological problems by physical methods. In agriculture the Foundation has supported physical projects like that at the University of Cambridge concerned with soil mechanics as it affects drainage and tillage; but under its auspices also a study-group of economists, agricultural scientists and practical farmers is attempting to deduce in essentially a scientific way the long-term principles which should underlie any shorter-term policy for British agriculture. In the social sciences, where the choice of men, projects and institutions for support has, of necessity, been opportunistic, the absence of any clear pattern reflects not only the

paucity of promising opportunities, especially for fundamental or adventurous research, but also the lack of coherence and systematic study in these subjects. Moreover, the review points out that the research which can be encouraged by the grants of private bodies is necessarily limited, and steady progress is unlikely until more public money is devoted to research as well as to teaching, so that the subject can be developed systematically and scientifically by an assured body of workers permanently established in universities.

This part of the review demonstrates clearly the primary function of the independent institution as providing the growing points of new knowledge, or new projects. The work on the care of old people, the basis of which in scientific research, especially fundamental research, is made clear, does, it is true, illustrate the same point; but it does not emphasize the related point that the independent institution should not be expected to commit its resources permanently to the support of activities the value of which, whether to society or scholarship, has been well attested. The value of the voluntary body or private institution lies precisely in its freedom to transfer its resources freely, to test the value of activities, projects and lines of investigation for which it would be premature or difficult to secure official or government support. Once the value of that line of investigation has been established, the voluntary body should seek to withdraw, leaving support increasingly to official sources, and to use its own resources at some fresh point on the frontiers of knowledge.

The dilemma which the Foundation and other such institutions are increasingly likely to face does not appear as clearly in this review as it did in its annual report two years ago, and also in that of the Carnegie United Kingdom Trust. The dilemma lies in choosing between helping, for example, academic activities during a time of public economy, and encouraging novel proposals which find it even more difficult to command a hearing. Yet the review, like Dr. Raymond Fosdick's recent review of the first forty years work of the Rockefeller Foundation, leaves us in no doubt where the primary responsibility of the independent institution lies.

It is encouraging to find that the principles and policies on which these two Foundations have been administered have so much in common. The Nuffield Foundation has less to say than Dr. Fosdick about those principles, but its policies are manifestly inspired by the same ideas of pioneering responsibility and willingness to risk capital adventurously on projects that the State will not or cannot support; and by the belief that promising men and creative ideas are the first essential. Judged by the ideas and practices set forth by Dr. Fosdick and also by Lord Beveridge, the Nuffield Foundation has acquitted itself well. The admirable record here so modestly told should stir more than the scientist to fresh thought as to the ways and means by which in the society of to-day the freedom of such bodies to continue their activities can best be ensured and the fullest use made of their services.

# TREATISES ON PHYSICAL CHEMISTRY

## An Advanced Treatise on Physical Chemistry

By Prof. J. R. Partington. Vol. 3: The Properties of Solids. Pp. lx+639. (London, New York and Toronto: Longmans, Green and Co., Ltd., 1952.) 70*s*. net.

## A Treatise on Physical Chemistry

Edited by Prof. Hugh S. Taylor and Samuel Glasstone. Third edition, in 5 Vols. Vol. 2: States of Matter. Pp. v+701. (New York: D. Van Nostrand Co., Inc.; London: Macmillan and Co., Ltd., 1951.) 75*s*. net.

THE general characteristics of Prof. J. R. Partington's "Advanced Treatise on Physical Chemistry" were well established by the first two volumes, and there is little new which a reviewer can say about the third. It maintains all the virtues of the earlier two: scrupulous care over detail and historical attribution, a clear and critical account of experimental methods, and a wealth of references (15,511 in the present volume) and numerical tables. These qualities appear all the more remarkable when one considers the sheer mass of material to which they have been applied in the three volumes of the treatise, and it becomes increasingly clear that staying-power is not the least of the author's qualifications for his task.

Those readers who disliked certain features of the earlier volumes will probably react in the same way to parts of the present one. For example, I am still unconvinced of the value of reproducing so many empirical equations: they are admittedly of no theoretical significance, and it may be doubted whether their inclusion is of much practical assistance, since it is impossible in the space available to give a critical account of their scope and accuracy. Similarly, some may feel that scant space is given to certain recent theories which are still in a fluid state—for example, the basis of hysteresis phenomena, or the mechanism of crystal growth. However, both these criticisms apply with less weight to the present volume than to the preceding one on liquids. This is not because of any change in Prof. Partington's approach, but because we understand the behaviour of solids much better than that of liquids. The need for empirical relations is therefore less: similarly, much more of the theory has stood the test of time and experiment, and thus escapes the somewhat severe censorship which the author applies to speculative and incomplete theories.

A number of particular points may be mentioned. The chapter on isomorphism is probably unique, and, although much of it is of purely historical value, it makes interesting reading. On the other hand, the whole subject of atomic and ionic radii in crystals is given a most inadequate treatment in four pages at the end of this chapter. The section on the elastic properties of solids gives an admirably clear exposition of a subject which often offers difficulties to physical chemists with a chemical upbringing. An excellent account is given of the thermal properties of solids, and the comparison of theory and experiment is critical and well-balanced. The whole book abounds with items of recondite information such as we expect from Prof. Partington, many of them presented with a certain dry humour. Thus, it is intriguing to be referred (p. vii) to a work entitled "Gelehrten-

mentalitätsbesonderheiten psychologisch-pathologisch betrachtet" (though tantalizing to be told that it is now unobtainable), and it would be interesting to know whether there is any foundation for the author's surmise (p. 266) that American writers are reluctant to use the name "specific heat" because it has for them a double meaning unknown to the rest of the world.

The first volume of the treatise edited by Prof. H. S. Taylor and S. Glasstone appeared in 1942, and the Second World War has delayed until now the publication of the second. If we accept the dictionary definition of 'treatise' as "a literary composition dealing systematically with a definite subject", then it is doubtful whether the present compilation can claim this title. The second volume contains five uncorrelated articles by different authors, each on a particular topic connected with states of aggregation, and there are naturally wide differences in the method of treatment. In this notice each will be discussed separately in turn.

"The Kinetic Theory of Ideal Gases" (187 pp.), by K. F. Herzfeld and H. M. Smallwood, builds up the subject progressively from the simplest foundations, great care being taken to explain the physical meaning of the expressions derived. The extension of the theory to imperfect gases is frequently indicated, and ultimately complex problems such as thermal diffusion and radiometer phenomena are dealt with. The exposition is throughout excellent, and there are many useful formulæ and tables of data. There is little direct account of experimental work, but numerous examples are given of the application of kinetic theory to practical problems.

In "The Thermodynamics and Statistical Mechanics of Real Gases" (166 pp.), by J. A. Beattie and W. H. Stockmayer, no account is given of experimental work, though some of the tables give data derived from experiment. The first two-thirds of the article consists mainly of a very thorough compilation of thermodynamic formulæ for single gases and gas mixtures in terms of the first four virial coefficients. It will certainly be useful to specialists wishing to tackle particular problems involving imperfect gases (though much of it has already appeared in an article in *Chemical Reviews*), but will be of little interest to anyone else. The remainder of the article, dealing with intermolecular forces, has more general appeal. A clear account is given of the theoretical interpretation of these forces, and of the way in which information about them can be obtained from observed equations of state. On the whole, this section is considerably more advanced and specialized than the remainder of the volume.

"The Liquid State" (68 pp.), by G. E. Kimball, has a misleading title, since, in fact, it contains only a description of some of the current statistical treatments of pure liquids. The theoretical exposition is clear; but there is little reference to experiment, and the reader might well end up with no conception of the real achievements or deficiencies of the theories described.

A successful treatment of a limited field is given in "X-Ray Analysis of the Solid State" (88 pp.), by J. G. White. The descriptions of the theory and practice of X-ray analysis are well designed for reading by the non-specialist, and are followed by a large number of examples ranging from simple ionic crystals to sterols and polymers. At times one sees (as in other articles) the disadvantage of a treatise consisting of separate articles on specialist topics: thus the short section on hydrogen bonding suffers in interest and in accuracy because no reference is made to the information obtainable from electron diffraction, spectra, or thermodynamic properties. In the main, however, this section gives a well-balanced and lucid account of the subject.

The final section, "The Colloidal State and Surface Chemistry" (183 pp.), by E. O. Kraemer, J. W. Williams and R. A. Alberty, covers a wider field than any of the other articles in this volume. Colloidal systems are not relegated to a mysterious domain obeying rules of its own, but are related to ordinary solutions, on one hand, and to macroscopic surfaces, on the other. The material is well chosen, with a judicious blend of theory and experiment, and although adequate attention is given to modern theories and physical methods of investigating colloids and surfaces, the classical experimental background is not neglected. The exposition is good, and this section should be valuable to students of chemistry in general.

Now that the compilation by Taylor and Glasstone has again got under weigh, we have in progress two major works on physical chemistry of comparable size, and it is of interest to attempt a general comparison of the two publications to date. Partington's treatise is characterized by its thoroughness and uniformity of treatment, and by the particular attention given to the experimental and historical aspects of the subject. Any scientific worker who wishes to obtain a complete and unbiased knowledge of what has been done in a particular field of physical chemistry will be well advised to consult Partington. (He may find relatively little about current theoretical views; but he will certainly find references to these.) On the other hand, the average student needs his information pre-selected (if not also pre-digested) to a greater degree, and he would be overwhelmed by the wealth of learning to be found here. Because of its multiple authorship, Taylor and Glasstone is much more uneven in its nature and quality, and must inevitably contain overlaps and omissions. Its general aim appears to be to present the current position of physico-chemical theory, rather than to describe the experimental or historical foundations of the subject. Some sections (for example, the last two in the volume under review) are well suited for reading by students, but others are too specialized and advanced for this purpose. The latter will be useful to research workers who wish to extend some branch of physical chemistry along its present lines of development, but they must turn to Partington if they seek the unorthodox view or forgotten observation which might transform the subject.

Both books should be in any well-equipped chemical library.

R. P. Bell

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# PRESTRESSED CONCRETE

## Prestressed Concrete

By Prof. Kurt Billig. Pp. x+470. (London: Macmillan and Co., Ltd., 1952.) 36*s*. net.

ENGINEERS first had to build with materials as provided by Nature such as timber, stone and earth. The coming of the industrial age has seen the application of man-made materials such as steel and concrete and their combination in reinforced concrete. For the past fifty years engineers have been building composite structures in which the weakness of con-

crete in tension is made good by the addition of steel reinforcement. The two materials are not ideally suited for working in harmony, for the low ductility of concrete limits the allowable steel stress to a fraction of that possible with high-strength steels.

The ingenuity of man, therefore, conceived the idea of self-straining the materials by putting the concrete under an initial compression in equilibrium with an initial tension in the reinforcement. This corresponds to a change in the origin of the concrete stress/strain curve, and the concrete can take differential stresses due to applied loading by reductions in the applied initial strain before getting into the danger zone of cracking due to tensile strains. It corresponds on an engineering scale to what the metallurgist does on a molecular scale when he cold-works metals. A new industry, that of prestressed concrete, has therefore come into being and is rapidly approaching maturity. Its adolescence is here chronicled in this book by Prof. Kurt Billig. The author is well qualified for such a task, for he has devoted many years to the subject and observed its growth in many countries.

The first part of the book is an almost encyclopædic account of the development to date. The pioneers did not foresee the loss in prestress due to shrinkage and creep of the concrete and creep of the steel. It was not until Freyssinet in 1928 obtained a solution by the combined application of high-tensile steel and high-grade concrete, with initial stresses so great that after all losses the effective prestresses were still adequate, that real success was obtained. Prof. Billig gives a full and well-documented account of the early attempts, the subsequent success, and even of developments that have not yet been brought to a commercial stage. As development proceeds, subsequent books will have to exercise a more selective method; but here we have a very useful source book for the future, although the material is not such as one would, in Great Britain, expect to find in what is described as a text-book. There is much to convince the engineer, interested in saving steel, that this new medium will have a definite place in the economy of the future.

It is noteworthy that the greatest development has taken place in countries which have to make sixpence do the work of a shilling, and that extra design costs are faced in order to make material savings. Britain has played its part in this development, but the United States have been able to adopt a somewhat more lavish attitude to materials and, despite their greater number of available technologists, are still relatively behindhand in the matter of prestressed construction.

The second and third parts of the book are more of the character of a text-book. Part 2 consists of a review of the general principles of design, and Part 3 deals with actual design problems, full numerical examples being given. Owing to the number of stages of loading to be considered in design, the book (and the subject) suffers from a multiplicity of symbols which does not make for easy reading. It is to be hoped that the Gothic symbols will not be perpetuated.

Data that have obviously cost Prof. Billig much effort—for example, tables of properties of sections—are put at the service of other designers. The book has much in it for those prepared to work hard, and, if necessary, to use their imagination; a chapter on the design of a radio tower does not include a single illustration to help the lazy. The publishers are to be congratulated on the quality of their work.

W. MERCHANT

# THE CIVIL SERVICE IN BRITAIN

## How the Civil Service Works

By Bosworth Monck. Pp. vi+258. (London: Phoenix House, Ltd., 1952.) 25*s*. net.

TO a large extent the steadily growing number of books on the Civil Service in the ten years or so since the publication of H. E. Dale's "The Higher Civil Service" and E. W. Cohen's "The Growth of the British Civil Service" have been concerned with the reform of the Civil Service and its adaptation to the problems of a society in which the Civil servant is required to take much more positive action than even a generation or so ago. Moreover, the range of the Civil servant's activities has widened immensely and in widening has made it much more important that there should be a far clearer general public understanding of what the Civil Service is, how it works and how the range and character of its activities depend upon the duties placed upon it by Parliament and, therefore, ultimately by the ordinary elector.

To a limited extent this task was attempted by T. A. Critchley; but he too was more concerned with the appropriateness of the Civil Service to the needs of to-day, and while much of his book is factual and descriptive, it is scarcely likely to appeal to, or be read by, the ordinary citizen who most needs to be enlightened as to the character of the Service and the way he conditions its activities. For some, Sir Edward Bridges's Rede Lecture two years ago might suffice, or again, Sir Frank Tribe's articles describing typical days in the life of a Civil servant. None of these is really addressed to the ordinary citizen, and the task of interpreting the Civil Service to him has not yet been accomplished. It is assayed once again by Mr. Bosworth Monck in the present work, but for all its merits—and they are considerable—the book can scarcely achieve this all-important objective.

Mr. Monck's main purpose is to provide an account of some of the methods by which Great Britain is governed, and the particular responsibilities of the major departments of the State. He is aware of the desirability of encouraging a clearer understanding between the taxpayer and the Civil servant whose work to-day touches so intimately so many sides of the taxpayer's life, but he seems a little too preoccupied with the Civil Service he is describing and to give insufficient consideration to the reader or class of readers for whom he is writing. The result is a book which covers too much ground and is unlikely to grip the reader whom it is most desired to attract.

The book is in five parts. First, it describes the general structure of the Civil Service and the character of those who work in it. An account of the way in which the estimates are prepared, the money voted and control exercised over expenditure follows. Next comes a survey of the whole process of government in which the Civil Service is set in its appropriate perspective with regard to the Government, to Parliament and to the ordinary citizen. The relations between the public service and the government of the day are discussed in a fourth section, before in the fifth and final section of the book Mr. Monck describes in some detail the activities and responsibilities of most of the major departments. Some omissions in this section, which occupies almost half the book, are obvious to the man of science. Nevertheless, it is admirably written and, while purely factual and descriptive, is informal, though it makes no attempt at giving such snapshots of a few

Civil servants at their daily work as Mr. Critchley did. The size and complexity of the Service have in no way hindered a clear exposition of the purposes and functions of the departments, but what has gone before has diverted Mr. Monck from the popular exposition that is our primary need to-day and the first justification for a new book on the Civil Service.

It is perhaps too much to expect one who was chairman of a group which five years ago produced for the Fabian Society a report on the reform of the higher Civil Service to refrain from discussing proposals for reform, but popular exposition and serious discussion of reform are ill consorts. Nevertheless, the book would have been more likely to achieve its declared purpose had the author practised such self-denial and eschewed the suggestions for reform which are made especially in his introduction but which are scattered through the first four parts. His sensible suggestions deserve more space than could be given, but Mr. Monck also brings in some questions like that of public ownership which are less relevant to the exposition of the nature of the Civil Service and how it works. The task of popular exposition must therefore be judged as an undertaking still to be accomplished.

R. Brightman

## THE TREES OF UGANDA

**The Indigenous Trees of the Uganda Protectorate**

By Dr. William J. Eggeling. Revised and enlarged by Ivan R. Dale. (Published by authority of the Government of the Uganda Protectorate.) Pp. xxx+491+76 plates. (Entebbe: Government Printer; London: Crown Agents for the Colonies, 1952.) 42*s*. net.

THE first edition of this work, published in 1940, was designed to be of service both to the botanist and the layman. Mr. Ivan R. Dale, who has prepared the revised and enlarged second edition, states that he has striven wherever possible to ease the difficulties of the layman, especially of field workers in government departments and sawmills. The book is very much more attractively produced than the first edition and is a credit to both printer and publisher. It is enhanced by the addition of coloured plates by 'Joy' (Mrs. Adamson), of twenty-one line-drawings previously published by the Imperial Forestry Institute, and of some more excellent photographs by Dr. W. J. Eggeling.

The appearance of this second edition is evidence of the very real need that exists in tropical countries for simple handbooks which will enable the field worker, without a specialized knowledge of taxonomy, to identify the trees he is likely to meet within his country. A handbook such as this can be made much simpler than a Flora by dealing only with the trees of one particular territory. Some authors have tried to simplify similar books by describing only the trees they regard as the commonest. This is most unsatisfactory, as the field worker is frequently thwarted or misled when the tree he is trying to identify is not in the handbook. Dr. Eggeling has, however, wisely used the term 'tree' in a wide sense and deals with all the trees recorded from Uganda, including those which appear to be rare or which are still unnamed. Rather more than seven hundred species are described; this figure conveys some idea of the immense botanical problem which confronts the forester in tropical countries.

The descriptions of the species on the whole are very good and include characters of bark and 'slash'. Such characters are of great value in tropical rain-forest where the leafy shoots and flowers of the timber trees are usually a hundred feet or more above one's head. At this time, when Floras are being prepared for tropical East Africa, for the Belgian Congo and for Angola, and the Flora of West Tropical Africa is being revised, many botanists, as well as field workers, will find these field descriptions most useful.

There is great scope in a work such as this for really vivid and practical keys. It is therefore disappointing to find that so much of the material has been borrowed, sometimes uncritically, from other works. For example, in the key to the genera of Moraceæ, the umbrella tree (*Musanga*), which has large digitately lobed leaves unique among Uganda Moraceæ, can only be keyed out by the following characters: "stamens erect in bud", "ovule erect from the base of the ovary-cell", and "male flower with 1 stamen". Forest officers are among the first to complain when such characters are used in Floras, and it is remarkable that they should be used unnecessarily in a book which has been written, used and revised by the forest officers themselves. As another example of the unsatisfactory borrowed keys one may cite *Capparis*, which is keyed out correctly as having the sepals in two series, but the only species in the book has the sepals in a single series and should, in fact, be transferred to another genus.

The descriptions of the families which have been added by Mr. Dale are sometimes useful, but too often will, one feels, confuse the field worker who is interested only in Uganda trees; if he has a wider interest there are other works to turn to. The fruit of the Apocynaceæ is, for example, described as "usually a pair of large follicles, but occasionally a berry"; then follows the description of fifteen species, twelve of which have berries (sometimes incorrectly referred to as "drupes" in this book). In the Violaceæ, a description of the only arborescent genus in Uganda—*Rinorea*—would have been more helpful than a description of the family.

Several corrections in nomenclature and taxonomy which have been made recently by botanists have been adopted in the new edition; but others have been overlooked. Some valuable original work has been contributed by H. C. Dawkins and G. Leggat, of the Uganda Forest Department, and by Dr. G. Cufodontis.

In this book the information which is derived from the author's and revisers' personal acquaintance with the trees they describe is of real value; but the material obtained from other sources is too often inapplicable to Uganda trees, and the book is consequently marred by a number of avoidable mistakes.

One cannot help feeling that the nomenclature, taxonomy and, above all, the keys of this edition would have been greatly improved if the reviser could have undertaken his work in one of the large British herbaria. It is time Colonial Governments realized that their botanists could serve them far more efficiently if they were allowed to spend at least one-third of their working-time at Kew or the British Museum, in the herbaria and libraries of which the British Commonwealth possesses a unique and incredibly rich heritage. As it is, the Colonial botanist must make the unsatisfactory choice between hurried visits and sacrificing a large portion of his leave.

R. W. J. Keay

# THE FLOOR OF THE ATLANTIC OCEAN

A DISCUSSION on "Floor of the Atlantic Ocean" was held by the Royal Society on February 26, at which the session during the morning was concerned with sedimentation, and during the afternoon with the deeper structure below the layers which can be sampled. The principal contributions during the morning were made by Dr. E. C. Bullard, Prof. P. H. Kuenen, Dr. J. D. H. Wiseman, Mr. B. C. Browne, Prof. F. P. Shepard, Prof. W. B. R. King and Dr. G. M. Lees. In the afternoon the discussion was opened by Prof. M. Ewing, and he was followed by Prof. J. P. Rothé, Dr. M. N. Hill, Dr. J. L. Worzel, Prof. H. H. Hess, Dr. T. F. Gaskell and Dr. G. P. Woollard. Those in the chair were, in order, Sir Cyril Hinshelwood, Prof. W. B. R. King, Dr. E. C. Bullard, Dr. R. Stoneley and Dr. E. D. Adrian.

In his introductory remarks, Dr. Bullard emphasized the importance of determining the methods of sedimentation in the deep sea; whether slow deposition over the whole area of the oceans, or whether cataclysmal slumping is the more important feature. He also stressed that, from the point of view of determining the climatological history of the earth from the study of the layering within a deep-sea core, it is essential to know whether in any sample the depositional sequence was exact.

Prof. P. H. Kuenen outlined the improvements in finding the characteristics of the surface layers of the deep oceans. He directed attention, in particular, to the great advances in coring methods, as shown by the largest core in the *Snellius* expedition of 1931 being only 2 m. in length in comparison with the 20 m. obtained by Kullenberg by means of his piston corer in the *Albatross* expedition, and longer cores than these are now being obtained. Further valuable contributions to the study of sedimentation from work at sea comes from the bottom photography which has been undertaken by Prof. M. Ewing and from the improvements in deep-sea echo-sounding. The latter can locate such buried surfaces as, for example, have been found by the Shell Oil Co. in shallow water at depths of 0–40 m. below the bottom. Prof. Kuenen directed attention to the necessity for international co-operation in the work of exploration of the bed of the deep sea on account of the high cost, and welcomed the existence of the International Joint Commission on Oceanography which has been formed under the auspices of the International Council of Scientific Unions. The Commission is organizing a new journal of research on the deep-sea floor (to be published by the Pergamon Press, Ltd.), and Mr. C. D. Ovey, the secretary of the Commission, is one of the editors.

With reference to the theoretical aspect of sedimentation, Prof. Kuenen directed attention to the large discrepancy which has arisen between the estimates by Twenhofel and others of the total sediment thickness and the measured values obtained by seismic methods. These indicate that, instead of an overall oceanic sediment thickness of 2–3 km., as was previously supposed, there is, in fact, much less. As a particular example, there is the $\frac{1}{2}$ km. of sediments measured by Raitt in the Pacific. Low values such as these are difficult to reconcile with the accepted values of the sedimentation-rate and the estimated age of the oceans.

Prof. Kuenen next discussed the transport of sediments in the deep sea by turbidity currents. These currents—at one time known as density currents—have not been observed in the oceans, but have been observed in the laboratory and in lakes. It is believed that they can be of sufficient velocity to transport the deep-sea sands, and are characterized by the graded bedding they produce and by the interstratification of deep-sea and shallow-water sediments in such regions as the mouths of submarine canyons. The distinction between turbidity currents and slumping or sliding lies in the ability of an individual particle to move freely in the former, whereas in the latter the material moves in bulk. Turbidity currents are sufficiently mobile for their momentum to carry them far beyond the slope, but slumps, on the other hand, stop at the point where the slope becomes small. Evidence for the existence of turbidity currents is not confined to the oceans but can be found in some continental rocks. For example, the graded bedding, and the interstratification of lutite in the ripple- and flow-marked graywackes of the Ventura Basin in California and elsewhere, can be attributed to this mechanism.

The turbidity currents can be of vast size and can extend to the middle of the ocean basins, but Prof. Kuenen found it difficult to believe that the cable-breaks on the continental slope and in the deep water off the Grand Banks following an earthquake in 1929 could have been caused by them. Ewing and Heezen collated the times at which the breaks occurred and concluded that, on the upper parts of the slope, velocities of the turbidity current had reached 55 knots. Later in the discussion other speakers showed doubts of this explanation of these breaks in the cable, but Prof. M. Ewing expressed confidence that these intuitive criticisms would prove incorrect. Prof. Ewing also mentioned that turbidity currents are not only confined to the regions of steep slope but are also found to exist on slopes as low as 1 in 500, and samples of undisturbed sedimentation can be obtained most satisfactorily on submarine hills of, for example, three thousand feet in height and five miles across. Prof. Kuenen later in the discussion noted that the turbidity currents are unable to cause erosion since they are in general overloaded, although they tend to be channelled down existing canyons. There is, he believed, no single origin from the submarine canyons, and they cannot all have been formed by subaerial erosion.

Prof. F. P. Shepard gave further evidence for the existence of turbidity currents from submarine canyons along the Californian coast. The Scripps Institute has particularly good opportunities for studying these canyons in shallow water, for at La Jolla there is one within five minutes sailing from the laboratory. Sediments are deposited in these canyons, and about every eight months the amount becomes unstable and disappears seawards. It is probable that small earthquakes can initiate this process. The material is undoubtedly transported to the deep water since, for example, foraminiferal material of shallow-water origin exists at the mouth.

Straightforward slumping cannot account for the transport, since the material is not uniformly layered in the area of deposition, and turbidity currents are the only explanation. Prof. Shepard agreed that these currents, while of primary importance in keeping the canyons clear, cannot account for their origin since their powers of erosion are inadequate.

Dr. J. D. H. Wiseman spoke of methods by which the climatic changes of the past can be detected in undisturbed deep ocean sediments. The first method is that of determining the total quantity of planktonic foraminifera in any level of the core by measurement of the percentage of carbon dioxide. These foraminifera act as temperature indicators rather than as indicators of the food supply, as is shown by their absence from antarctic waters, and consequently the quantity of carbon dioxide deposited depends directly on the temperature. Another method of determining the temperature depends upon the proportions of warm-, temperate- and cold-water forms of foraminifera found at any level in a deep-sea core, and a third method is the measurement of the proportion of the oxygen-18 isotope. This last method, which has been developed by Prof. H. C. Urey in Chicago, has been checked by investigations of Recent sediments. Dr. Wiseman showed there is agreement between the oxygen-18 and the carbon dioxide maxima down the length of a core. The rate of sedimentation of a core can be obtained by assuming that the rate of sedimentation of iron or titanium is constant and that, as would be expected on this hypothesis, there is a reciprocal relationship between the ferric oxide content and the carbon dioxide content.

Mr. B. C. Browne described the gravity results obtained by himself and those obtained by Prof. Vening Meinesz in the eastern Atlantic and in the English Channel. The scatter in the regional isostatic gravity anomalies is considerably greater in the deep water than in the shallow, the mean value for the Atlantic being $+ 11 \pm 19$ mgal. in comparison with $+ 7 \pm 10$ mgal. in the Channel. This increase in variation in the ocean can probably be associated with changes in the sedimentary thickness such as have been found by seismic refraction shooting. Mr. Browne considered that the rugged topography found in some areas is caused by the basement rocks protruding through pools of sediment, and he urged that there should be a combination of seismic and gravity observations to determine the extent of the association between the anomaly variations and the sediment thickness.

Dr. G. P. Woollard and Dr. J. L. Worzel agreed that many of the gravity anomalies at sea can be accounted for by the variations in sediment thickness and gave as known examples the sediments which accumulate in the depressions caused by elastic bending of the crust around oceanic volcanoes, the sedimentary layers of the continental shelf, and the great thickness of sediments found in the Puerto Rico Trench. Prof. Ewing later reported that, owing to the great magnitude of this thickness, attempts at measurement have three times failed. It may be deduced, however, that it is at least 9 km., which is enough to satisfy the gravity field, and for this reason it appears that there is no deep root of lighter rock such as is required by the Vening Meinesz theory of the formation of geosynclines. Dr. Woollard said that the association between sediment thickness and gravity anomaly does not always exist on the continents, and gave an example of a trough filled with sediments denser than the surrounding rocks, which nevertheless possesses a large negative free-air gravity anomaly.

Dr. J. L. Worzel described briefly the results obtained from six hundred gravity stations in the Atlantic, and explained that the common belief that the average free-air anomaly for the oceans is slightly positive is incorrect. If those stations at which the water depth is less than 3,000 m. and greater than 6,500 m. are rejected, the average free-air anomaly is $- 3{\cdot}2$ mgal. The number of stations with a negative free-air anomaly was 258 and the number with a positive anomaly 195.

Prof. W. B. R. King described pebbles which have been obtained in cores in the eastern Atlantic in about the latitude of 50° N. These pebbles include several of basalt with the corners showing glacial scratches, some limestone pebbles with trilobite shell fragments, some coarse sandstones and mica schists. These, and the clay in which they were embedded, are all of glacial origin and indicate the importance of ice as a method of transportation of deep-sea sediments. How far this method extends to the south in the Atlantic is not known.

Dr. G. M. Lees objected to the prevalent concept of the oceans as static units and referred to the downwarping which has been known to occur and would sink the continental surface to oceanic depths. He said that he has no confidence in the deductions from the measurement of gravity at sea which lead to the belief in fundamental differences between oceans and continents, and, as an example of the uncertainty of interpretation of gravity results, he quoted measurements from north-west Africa where there is a discrepancy of 20,000 ft. between what is supposed to exist from the gravity results and what is found in seismic prospecting. The conception of the permanence of the oceans is so firmly thrust upon the geologists that they have arranged their interpretation to fit and have rejected any hypothesis which allows the extension of geological structures into the deep sea. Later in the discussion this last point was again raised, and it was apparent that geophysicists generally agree that the earth movements producing the continental surface features can extend without break into the oceans; an example of this is the continuation of the San Andreas fault for two thousand miles into the Pacific.

The session on the deep structure of the Atlantic was opened by Prof. M. Ewing, who outlined the areas investigated by himself and his colleagues by coring and seismic refraction shooting. These areas include the continental margin of the western Atlantic, the Caribbean area and the deep North Atlantic. All the deep stations have shown the same general structure for the earth's crust; it consists of about 5 km. of water overlying ½–1 km. of unconsolidated sediments, and below this there are 4–5 km. of crystalline rocks which are probably basaltic. This interpretation of material is based on the known compressional wave velocities and on the existence of olivine basalt on the mid-Atlantic ridge and islands. At the base of the basaltic layer is the Mohorovičić discontinuity, and below this the earth's mantle extends to great depths and is probably of the nature of peridotite. The work in the Caribbean indicates that, contrary to earlier beliefs, this sea is by nature representative of the deep sea and not of a sunken continent.

Sections across the continental shelf and slope show that the Mohorovičić discontinuity slopes upwards from about 200 miles inside the coast-line, where it lies at a depth of 30–40 km., to about 100 miles out to sea where, as under the deep ocean, it lies at a depth of 10–12 km.

The configurations of the layers lying above the Mohorovičić discontinuity are similar on all sections across the continental shelf and slope, although there are changes in the horizontal scale. They show the continental basement rock sloping seawards with wedge-shaped sedimentary layers lying on it.

Prof. Ewing next discussed the dispersion of surface waves in the sea bed produced in earthquakes. The information agrees with the theoretically derived dispersion for a layer of water overlying the rock and indicates a similarity of structure for the beds of the Atlantic and Pacific Oceans. In spite of the sediment thickness in the Pacific being half that of the Atlantic, this cannot be observed from the dispersion, and it is apparent that for these surface waves the sedimentary layer acts as water.

Dr. M. N. Hill showed the results he and Mr. A. S. Laughton have obtained with seismic refraction shooting in the eastern Atlantic during 1952. These, while small in number compared with those obtained by Prof. M. Ewing, confirm that the Mohorovičić discontinuity lies at a depth of about 11 km. below sea-level. Above this level the velocities are such as would be expected for basaltic rocks, and there is no evidence for the existence of any lower-velocity rocks between this layer and the base of the unconsolidated sediments. The sediments are variable in thickness; in some areas of rugged-bottom topography there appears to be none, and in other areas there is as much as 2·6 km. The average thickness is about 1 km. This thickness is greater than that found by Ewing in the western Atlantic, but the difference can, in part, be attributed to different assumptions concerning the velocity of compressional waves in the sedimentary layer.

A section from the central English Channel to the deep water of the Atlantic indicates that there is a slope of the basement rocks below the semi-consolidated sediments which is more gentle than that found by Bullard and Gaskell in a line farther to the north, and it suggests that the latter happens to coincide with an extension of the structure forming the south coast of Devon and Cornwall out towards the edge of the shelf. It is possible that this structural feature extends down the continental slope, since in this region the topography of the slope is exceptionally rough.

Dr. T. F. Gaskell described the three types of crustal structure which he and Mr. J. C. Swallow have obtained by refraction shooting in the Pacific Ocean during the recent world cruise of H.M.S. *Challenger*. It appeared that these three types are also to be found in the Atlantic. The first type is typical of the deep ocean and consists of about $\frac{1}{2}$ km. of sediments lying on a layer in which the velocity corresponds to, although it is slightly lower than, the basaltic layers referred to by Ewing and Hill. The second type is similar to that of the deep ocean except that interposed between the sediments and the basement rock lies a layer in which the velocity is such as would be expected for volcanic material. This interpretation is supported by the existence of volcanic islands and sea mounts in those regions where this succession is found. The volcanic cores themselves are such that the velocity of compressional waves is similar to the basement rock. The third type, which is typified by stations on the landward side of the andesite line, shows basement velocities less than those in the other types and similar to those in the continental surface layers.

The Atlantic results of H.M.S. *Challenger* were mostly in the Bermuda region, and these show the second type of structure. The sea depth is about 5 km., and the unconsolidated sediment depth $\frac{1}{2}$–1 km. Below the sediments there are lavas $1\frac{1}{2}$–$2\frac{1}{2}$ km. in thickness lying on the basement rock. There is only one result from the Atlantic which belongs to the deep ocean type.

Prof. J. P. Rothé described the distribution of recent earthquake epicentres in the Atlantic and Indian Oceans and the Mediterranean Sea. The line of activity extended from the Red Sea to the Carlsberg Ridge and thence to the south of the Cape of Good Hope, joining with the mid-Atlantic ridge which passes northwards through Tristan da Cunha, St. Paul's Rocks, the Azores and thence to Iceland. The Mediterranean line of earthquake activity extended westwards as far as the mid-Atlantic ridge. Within the area roughly bounded by these lines of activity there are continental rocks, and outside there exists the typical oceanic structure. Prof. Rothé suggested that perhaps there is not the clear-cut distinction between the velocities of compressional waves in the continental type of surface-rocks and those in the basaltic layer. In support of this, he quoted an example on land where there is an obvious and typical continental surface and yet giving high velocities which Ewing associated with basaltic rocks. In spite of the evidence from seismic experiments at sea, it is therefore still possible that the sialic rocks form the sea bed below the sediments within the area bounded by the earthquake belts. This hypothesis is supported by the velocities of surface waves from earthquakes which traverse this area.

Prof. H. H. Hess stated the importance of obtaining pieces of rock from below the Mohorovičić discontinuity and believed it to be not impossible that these would be different if obtained from under the continents rather than from below the oceans. Peridotitic bombs from oceanic volcanoes probably represent the material of the mantle, although it is possible that they are aggregations from basaltic rocks. It is also probable that the periodotites obtained from St. Paul's Rocks are representative of the layers below the Mohorovičić discontinuity.

Prof. Hess discussed the problem of guyots. He explained that, contrary to previous suppositions, their top surfaces were all of later origin than pre-Cambrian, and these surfaces must have sunk many thousands of feet below sea-level in post-Palæozoic times. This is demonstrated by the existence of Cretaceous and Eocene fossils in the surface layers. He believed the Pacific guyots, which lie on lines, represent the upward edge of convection cells in the earth's mantle and that the island arcs represent the downward edge.

Dr. E. C. Bullard described the significance of the measurements of heat flow which are being made at sea. On land, measurements have been carried out for many years in mines and boreholes and have demonstrated that, within a factor of 2, the value of the heat flow is $10^{-6}$ cal. cm.$^{-2}$ sec.$^{-1}$. This heat flow is commonly supposed to be accounted for by the radioactivity of the continental surface rocks. Hence, it was deduced that the heat flow under the oceans would be less and that this differential heating

between the oceans and continents could account for convection currents in the mantle and thereby many of the earth's structural features. Measurements by Maxwell and Revelle in the Pacific, and by Bullard in the eastern Atlantic, have shown that these conclusions are incorrect, the heat flow for the Pacific being roughly equal to the continental value and that for the Atlantic being slightly less and about 0·7 times the continental value; the expected heat flow, on the old hypothesis, was about 0·25 times the continental value. Explanation of this value for the heat flow is difficult, but might be accounted for by the total quantity of radioactivity in any vertical column being independent of the location of that column, in the same way as there is an equality of mass between columns.

In reply to a query by Dr. Lees concerning the heat flow from the oceans and continents being approximately the same, Dr. Bullard expressed the firm belief that this does not indicate that continents could have existed where now there are oceans, since the measured differences in structure are too great. There is, however, the irreversible possibility of continents extending into regions where there are now oceans.

M. N. Hill

## HATHERLY BIOLOGICAL LABORATORIES, UNIVERSITY COLLEGE, EXETER

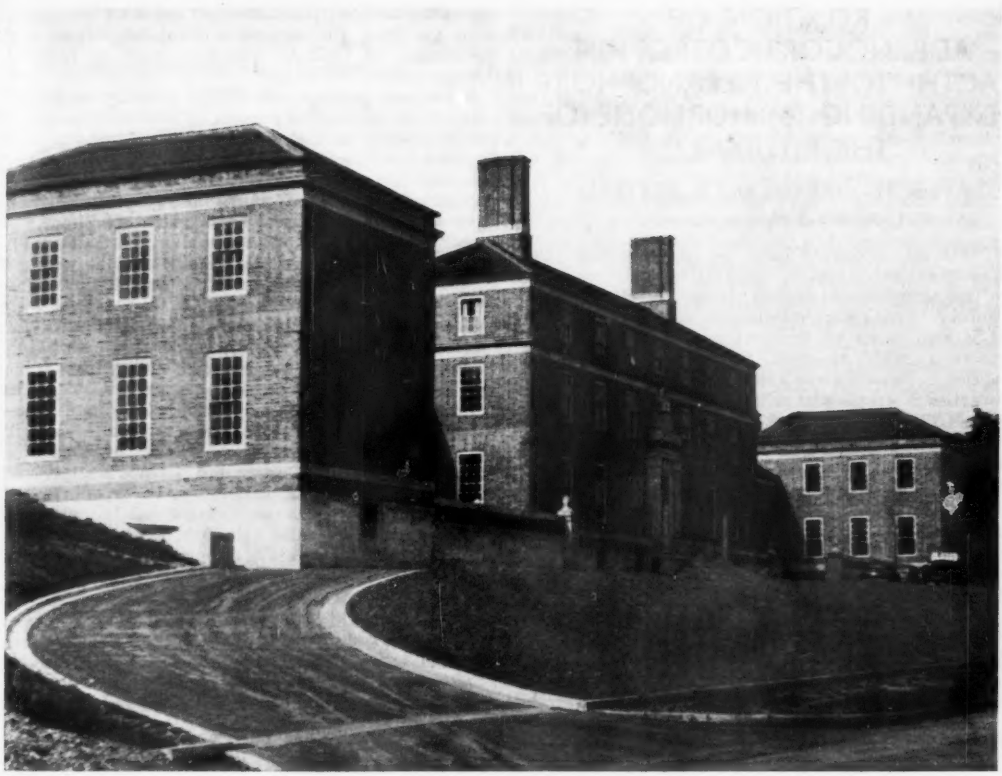
By Prof. JOHN CALDWELL

On April 23 the Hatherly Biological Laboratories of University College, Exeter, were formally opened by Sir Edward Salisbury, director of the Royal Botanic Gardens, Kew, in the presence of a gathering representative of the universities and learned societies, as well as of local and national bodies. In his address on the "Place of Biology in the University Curriculum", Sir Edward dealt with the value of the discipline of biology in a liberal education and the part that universities can play in developing a broader and more general approach to the whole subject of biology and its implications, deploring the narrow specialization which tends to isolate the biologist, and not only biologists, from the sympathy and understanding of the community. The chair was taken in the absence of the president, the Most Hon. the Marquess of Salisbury, by the deputy president, Mr. B. G. Lampard-Vachell. The thanks of the company to Sir Edward Salisbury was expressed by the principal of the College, Sir Thomas Taylor. Thereafter, before the company moved off to inspect the laboratories and the demonstrations set out in them, a brief account of the building was given by Prof. J. Caldwell, director of the laboratories. Plans were prepared for the laboratories after the College received a bequest from Mrs. Ellen Heath, of Exeter, towards the erection of a building to be associated with the name of Hatherly. The additional money was obtained through the generosity of the University Grants Committee, and the foundation stone was laid by the president of the College on July 28, 1948 (see *Nature*, **162**, 505; 1948).

The laboratories, which were built to the design of Mr. E. Vincent Harris, consist of a central block with entrance hall and private rooms for members of staff and two wings facing south-east. From this there project to the west five bays, each two stories high, with the main laboratories in them. The advantage of this arrangement is that the north-facing sides of the laboratories are almost completely of glass, plate-glass sheets 11 ft. by 7 ft. in the lower floor and 7 ft. square on the upper. These ensure that there is excellent natural light in the laboratories and the orientation of the laboratories shields these windows from direct sunlight.

Three Departments are housed in the building—Botany, Geology and Zoology. The first has two large junior laboratories each approximately 60 ft. by 30 ft., and one advanced laboratory 60 ft. by 25 ft.; the two former have preparation and store rooms attached. The mycology laboratory, with an annexe as a sterilizing room, is 30 ft. by 25 ft., as is the lecture room above it and a fifth laboratory and reading room above that. These are in the wing to the front of the building on the south side. There are, in addition, private laboratories for the members of staff, an office and three research laboratories roughly 20 ft. square. The Department of Zoology has its laboratories in the third and fourth bays. There are two laboratories, one on the ground floor and one on the upper floor, and a series of research

Hatherly Biological Laboratories. Main laboratories with north lights



Hatherly Biological Laboratories. Central block

rooms for members of the staff and postgraduate students. The Department also has in the north wing to the front of the building a small animal room, an aquarium room (corresponding to the mycology laboratory in the other wing), a lecture room and a laboratory equipped for physiology.

The Department of Geology, which, though new, is rapidly developing, has one large laboratory and research and private rooms. The fifth bay has on the ground-floor the lecture-theatre, which accommodates 110, and above that the museum–reading room, common to all three Departments. In addition, there are dark-rooms, constant-temperature rooms with controlled humidity and temperature, a workshop and store-rooms. Provision has been made for a resident caretaker and for a technician.

The exhibits included, in the Department of Botany, herbarium material of Devon plants, especially of Dawlish Warren, and a collection of floras and books dealing with them. There was also a representative collection of Coniferæ from the College arboretum. Cultures and material illustrating the survey of animal mycoses being undertaken with the support of the Agricultural Research Council by Dr. G. C. Ainsworth and Mr. P. K. C. Austwick were on show, as was material dealing with chrysanthemum, broccoli and narcissus virus diseases, with a range of host plants, and cytological studies of the nuclear aberrations which are associated with them. This work is carried out by Prof. J. Caldwell, Dr. J. Wilkinson and Mr. D. A. Govier. There was a very extensive collection of drawings and photographs illustrating the larger fungi of sand dunes, the ecology of which is being studied by Mr. T. J. Wallace. Further material illustrated Dr. T.-T. Chan's work on the developmental morphology of the narcissus plant, and there was in addition a laboratory devoted to specimens of the current work of the undergraduate members of the Department.

In the Department of Geology there was displayed material illustrating the work being carried on, which includes Mr. A. Stuart's study of the Pleistocene of the Bideford Bay area, and of the terraces of the Lower Exe Valley and the petrology of the Carboniferous Igneous Rocks of Bantry Bay, Ireland. Dr. D. L. Dineley is working on the geology of a part of Spitsbergen and on the Conodonts and Ostracoderms of the Devonian and Carboniferous rocks of the south-west, and of the Welsh Border, while Dr. R. N. C. Bowen is studying the Foraminifera and Ostracods of the Tertiary rocks.

In the Department of Zoology exhibits illustrated Dr. R. J. S. Hawes's work on the parasitic Protozoa of invertebrates, Mr. G. G. Vicker's studies on the ticks of south-west England and Mr. I. J. Linn's studies on the ecology of small mammals. In addition, there was material representative of Mrs. C. Harvey's work on fertility problems and Miss R. A. Manwaring's ecological studies on the fauna associated with certain marine algæ. Further material illustrated Mr. M. J. Delaney's taxonomic and ecological studies on the Thysanura, Mr. P. D. Gabbutt's ecological study on the wood cricket and Prof. L. A. Harvey's ecological survey of Lundy.

# RELATION OF ADRENOCORTICOTROPHIN (ACTH) TO THE MELANOPHORE EXPANDING (B) HORMONE OF THE PITUITARY*

By Prof. H. WARING and B. KETTERER†
University of Western Australia

TWO laboratories[1,2] have recently claimed that adrenocorticotrophin (ACTH) is identical with the melanophore-expanding hormone (B) of the pituitary. This claim has obvious academic interest; but it also raises an issue of importance for those concerned with research technique and clinical practice, because the assay for melanophore-expanding properties is simple and reliable[3], while the currently used ACTH assays are not.

Consideration of this claim demands, as a preliminary, a brief survey of the relevant information about both excitants.

## Adrenocorticotrophic Hormone(s)

Information from hypophysectomy, injection of extracts, and clinical observation shows that the pituitary in mammals controls adrenal cortical size, lipoid distribution, ascorbic acid content and, indirectly through the release of cortical steroids, it controls eosinophil numbers and lympholytic activity[4]. We do not know whether all these effects are mediated by one hormone (ACTH) manufactured in the gland, or by several. In particular, we do not know the significance, if any, of ascorbic acid depletion in relation to steroid release. It is important to emphasize this because ascorbic acid depletion has been arbitrarily chosen as the popular assay for ACTH activity and by sheer weight of words has become almost synonymous with it, to some people. It is certain that, by various procedures, extracts can be produced with one or other activity preponderant. So without further consideration the question before us must be more precisely phrased as: Is B hormone identical with all, or only part of the totality of ACTH, or entirely independent of it?

With regard to the seat of origin, cytological evidence[5] is sufficient to show that the anterior lobe of the pituitary is involved; but we have found no evidence based on surgery to show that the intermediate lobe is not involved and, in this context, we note that the pituitary grafts which have maintained the adrenal with greatest success have contained intermediate lobe as well as anterior lobe of the pituitary[6].

A considerable amount of work has been done on the chemistry of ACTH. In 1943 Li *et al.*[7] and Sayers *et al.*[8] independently prepared similar proteins which exhibit ascorbic acid-depleting, adrenal cortical size-maintaining and other properties. These proteins appeared pure when judged on physico-chemical criteria, and for some time it was thought that they were the adrenocorticotrophic hormone. However, biological assay of the Li preparation showed 0·02 I.U./mgm. pressor activity[7], and the International Standard powder (ACTH), which is prepared similarly, contains 0·35 I.U./mgm. B activity[9]. So it appears that the 'pure protein' contains contaminating material of considerable biological potency but insufficient in bulk to manifest itself in physical determinations for purity.

Some and perhaps all ACTH activity in simple extracts, or in purified protein, is relatively stable to partial hydrolysis with hydrochloric acid and pepsin. In 1948 Li[10] demonstrated that in digested extracts the ascorbic acid depleting activity resided in a peptide. Attempts to purify the peptide activity have resulted in material with up to 300 times the ascorbic acid depleting potency of standard powder[11]. A similar preparation of Lesh *et al.*[12] had an average molecular value of between 2,500 and 10,000. The isolation of a large molecular peptide material with such a high potency suggests that the activity of the 'protein hormone' might simply be due to slight adsorbed contamination with material of this type. Dr. Stanford Moore's work, as recorded by Stack-Dunne and Young[13], is consistent with this. Moore subjected Sayers's protein to ion-exchange column chromatography and got a separation into a major component, acid and inert, and a trace component, basic and very potent. (The alternative proposition, that a molecule such as Brink's, which we have assumed has a molecular value similar to Lesh's preparation, is actually a part of the parent molecule and is released by various procedures, would mean that weight for weight its activity must be increased at least 30 times by the simple act of separation. Furthermore, one would expect at least a 10 per cent yield of such an activity, but Stanford Moore's experiment produced it only as a trace (on a weight basis).) Apparently oxycellulose is another adsorbent which can separate ascorbic acid depleting activity from the protein. Li and his associates[14], by a combination of adsorption and chromatography with oxycellulose, have obtained a basic material within the same activity range as Lesh's and Brink's fractions. When this material was hydrolysed, only eight different amino-acids were found in the hydrolysate.

In all this recent work, adrenal ascorbic acid depletion has been used for measuring ACTH activity and at present it appears highly probable that total ACTH activity is dependent upon more than one chemical entity. Thus Reinhardt and Li[15] found that when a protein ACTH preparation was subjected to peptic hydrolysis its ascorbic acid depleting activity was doubled, adrenal weight increasing activity reduced and its lympholytic activity increased several fold. When an acid hydrolysate was used and the undigested protein removed, the ascorbic acid depleting activity was greatly increased and the adrenal weight maintaining activity was greatly reduced. An even more striking separation between two activities considered to be adrenocorticotrophic has been reported by Stack-Dunne and Young[13]. They prepared crude alkaline extracts of anterior lobe and purified growth hormone with adrenal weight maintaining/ascorbic acid depleting ratios up to 5,000. It could be objected that an interpretation of separate chemical entities for each biological activity must be treated with caution because changes in the physical aggregation of injected material can modify the several responses differentially. Hayshida and Li[16] showed that precipitation of protein preparation in alum solution increased both adrenal weight and lympholytic activity twofold; similar precipitation of a peptide increased the lympholytic activity several fold, but the adrenal weight activity remained unchanged. However, this type of phenomenon could

* Substance of a paper read at the 1952 meeting of the Australian and New Zealand Association for the Advancement of Science.
† On salary from the Australian National Health and Medical Research Council.

scarcely account for the result of the Stack-Dunne and Young fractionation.

## Melanophore-expanding Hormone (B)

In colour-changing vertebrates, notably Amphibia, there is completely satisfying evidence that a hormone (B) is produced in the intermediate lobe of the pituitary, and its liberation into the blood-stream evokes darkening of the skin[17] both by expanding melanophores and potentiating the formation of more melanin; there is new unpublished evidence that the presence of endogenous B antagonizes adrenalin hyperglycæmia in intact toads[18]. In warm-blooded animals that do not change colour, B hormone, although present, has not so far been shown to subserve any function, although experiments at the pharmacological level show that in these animals also it has anti-adrenalin properties[19] and there is a *prima facie* case for further investigation of its potential role in hyperpigmentation.

There has been no comparable systematic work on the chemistry of B to parallel that on ACTH outlined above. There has, however, been work at the pharmacological level and the relevant parts of this are considered below.

## Is B Identical with the Totality of ACTH or Part of it?

There is factual information only for assessing whether or not B is identical with ascorbic acid depleting activity; any attempt to equate B with total ACTH, or another part of it, is pure speculation. Even for consideration of this more limited objective there is a major qualification to all the points that can be made in favour, or against, the proposition. There is evidence[20] for some pituitary control of cortical tissue in Amphibia, but there is, as yet, no information about the measurement of ascorbic acid depleting activity in these animals. Equally, ascorbic acid depleting activity can be measured in mammals, but no measurement of B activity can yet be made in them. Until this is resolved—and it is probably resolvable—there will always remain the doubt as to whether the same molecule will have comparable biological effects in the two animal groups. This suspicion is not just fanciful. A number of discordant data from posterior lobe studies are most plausibly explained in this way and, more specifically to our present problem, although there is ample evidence for some ACTH control of cortical activity in birds[21], pituitary extracts containing mammalian ascorbic acid depleting activity have no effect on the ascorbic acid content of bird adrenals[22]. With this qualification, the relevant data are here assessed:

(*a*) The only parallel assays on separated pituitary lobes which have been performed with the intention of showing whether or not B measured in Amphibia, and ascorbic acid depleting activity measured in mammals, have a separate origin are those of Reinhardt *et al.*[23] on the anterior and intermediate lobes of *Rana catesbiana*. These assays show that activity which depletes the rat adrenal of ascorbic acid is more concentrated in the anterior lobe than in the intermediate lobe and vice versa for B activity.

(*b*) Sulman[24] reported a rise of both ascorbic acid depleting and B activities in the blood of human patients exhibiting hyperpigmentation, Cushing's syndrome, Addison's disease, pregnancy, and operational stress, etc. Johnsson and Hogberg[1] give similar information. According to the authors, this evidence shows that B activity stimulates the adrenal cortex on the basis of the well-known check-balance system of pituitary excitants with their target-organ secretions, but another interpretation is possible. The relationship of the pituitary to its various target organs is not a simple one, and the following well-known examples show that a pituitary hormone is sometimes affected by steroids not under the control of that particular pituitary excitant. (i) The adrenal cortex secretes minero-corticoids (of deoxycorticosterone acetate type—DCA) and gluco-corticoids (of cortisone type). ACTH stimulates chiefly gluco-corticoid release, and hypophysectomy does not inhibit minero-corticoid production. Yet injections of DCA, as well as cortisone, inhibit the release of ACTH[24]. (ii) Œstrogen injections potentiate melanogenesis correlated with hyperplasia of the intermediate lobe[25], but B is not gonadotrophic. (iii) Castration increases pituitary antidiuretic hormone (ADH)[26], but the latter is certainly not gonadotrophic.

(*c*) Both B and ACTH, unlike other pituitary hormones, are heat stable over a wide *p*H-range, and both are more stable to peptic than tryptic digestion[17].

(*d*) Johnsson and Hogberg[1] found that both B and ascorbic acid depleting activity occupied the same position on a paper chromatogram using the phenol/water solvent system. This is not a specific test, since a number of proteinaceous substances behave similarly[27].

(*e*) Sulman[28] was able to get a melanophore response to 0·01 gamma of a commercial 'ACTH' preparation. He argued that such high activity could not be due to a contaminant; but actually a preparation need only contain 0·3 per cent by weight of a peptide like that of Brink *et al.* to be as active as standard powder in ascorbic acid depleting activity. The only kind of investigation along these lines which will have any real meaning is a series of parallel ascorbic acid and B assays on a quantitative basis. Reinhardt *et al.*[23] have done this, although they do not give any information which enables us to assess the reliability of their B assay technique; no correlation between the two activities was found.

(*f*) Reinhardt *et al.*[23] state that caustic soda treatment destroys ascorbic acid depleting activity but increases B activity (potentiation). This is a generalization which requires further comment. Material prepared by adsorption on to, and elution from, charcoal or oxycellulose (which would remove much protein), when treated with caustic soda, loses both ascorbic acid depleting activity and B activities at a similar rate. On the other hand, if a simple pituitary extract, or material which has been purified by *some*, but not all, fractional precipitations, is treated with caustic soda, its B activity is potentiated and its ascorbic acid depleting activity is destroyed. This B-potentiation is only shown by Amphibia which have been in use a short while; those which have been in use longer give the same response to caustic soda treated extracts as they would to untreated extracts[29]. It appears that, in the presence of pituitary protein, B activity is protected from destruction by alkali, and further, that an extra activity is produced which is detectable only by Amphibia which have been in use a short time. This seems clear evidence that B and ascorbic acid depleting activity are not referable to an identical configuration. The new observation[9] that when *Xenopus* has become insensitive to potentiated B from posterior lobe pituitary extracts it still reacts to potentiated B in ACTH extracts will inevitably lead to speculation about the possibility of a hydrolysate

of ACTH having melanophore excitant properties, but such speculations are premature.

(*g*) Morris[29] claimed that Landgrebe and Waring methods for obtaining B by carbon adsorption eliminated the ascorbic acid depleting activity. We cannot confirm this, nor can Reinhardt *et al.*[23].

(*h*) Deliberate attempts have been made to bring about a complete separation of B and ascorbic acid depleting activity. Morris[29] used counter-current distribution, and Reinhardt *et al.*[23] used oxycellulose column chromatography and filter paper electrophoresis; the separations achieved were substantial but not complete.

## Conclusion

From the foregoing, B and ascorbic acid depleting activities appear chemically similar but are separable in certain circumstances. This probably means that these activities reside in different molecules in the gland and bear a close but fortuitous chemical relationship; their apparently different anatomical origin, and in particular the evidence from *Rana*, are consistent with this. However, even if B is not identical with ascorbic acid depleting activity, the evidence to date neither favours, nor precludes, B from a part in the pituitary adrenocorticotrophic system which appears to be complex.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# NEWS and VIEWS

## Prof. R. Courrier, For.Mem.R.S.

Prof. Robert Courrier is a graduate in medicine and in natural science of the University of Strasbourg, of which he became a member after serving in the front-line throughout the better part of the First World War. Bouin was then the head of the Department of Histology, and Ancel of Embryology, and Courrier was among the first of a distinguished line of investigators whose work derives from the union of interests of these two great pioneers of the scientific study of the physiology of reproduction. In 1927 he went to Algiers, where he was given charge of histological teaching in the Faculty of Medicine. He became a full professor in the Faculty in 1936, and two years later was invited to the Collège de France as professor of experimental morphology and endocrinology. Appointments to the Collège are not determined by the interests of previous holders of chairs, and new professors are chosen, essentially as research professors, on the basis of their eminence in the field of study they pursue. In the fifteen years since he has been in Paris, Courrier has established a magnificent department which is known to endocrinological research workers throughout the world. In 1941 he was made a member of the Academy of Medicine, and in 1944 of the Academy of Sciences. Election to the foreign membership of the Royal Society is the most recent of a series of national and international honours which he has received.

Courrier's first work was concerned with the control of secondary sexual characters in mammals, and with the regulation of the œstrous cycle, and his early papers reveal a maturity and an originality of approach which have continued to mark all his subsequent work. After some very detailed studies of reproduction in the cat, Courrier took the opportunity offered by his post in Algiers of extending his inquiries to the monkey of North Africa, *Macacus inuus*—a species which he is still investigating in his Paris laboratories. Among the many original observations dating from this period was his demonstration that the epithelium of the uterus masculinus in the male monkey responds to œstrogen in the same way as does the vaginal epithelium in the female—a discovery which was simultaneously reported in Great Britain and the United States, and which forms the basis of many of our present ideas about homological relations between the male and female reproductive organs. About this time, Courrier also became greatly interested in the functional and quantitative aspects of the synergism and antagonism of androgenic, œstrogenic and progestational hormones. As a result, his attention became focused more and more on the biological properties of the corpus luteum, and on the endocrinological factors which underlie the changes of gestation. A book he published on this subject in 1945 remains one of the most valuable and up to date on the subject. More recently, Courrier has become interested in the properties of a variety of synthetic chemicals which reproduce the behaviour of biological hormones; and he has also used radioactive substances in the study of hormonal action.

Courrier's considerable output of scientific work has not prevented him from playing a big part in scientific administration, and his election in 1948 to the office of Secrétaire Perpétuel of the Academy of Sciences not only reflects the favourable light in

which the administration of his own Department is viewed by his colleagues, but also the impetus which, as a member of the Conseil supérieur de la Recherche Scientifique, he has given to the post-war development of French science. Men of science outside France will remember with gratitude the lead he has taken in organizing international colloquia at the Collège de France on various subjects, especially those relating to the physiology of reproduction.

## Dr. H. J. Muller, For.Mem.R.S.

ANOTHER distinguished man of science who has just been elected a foreign member of the Royal Society is Dr. H. J. Muller. Hermann Joseph Muller was one of the three collaborators of T. H. Morgan whose co-ordinated experiments on *Drosophila* between 1910 and 1916 established the chromosome theory of heredity. Muller was especially responsible for working out the principles of crossing-over between chromosomes or strings of genes, principles now believed to be universal in sexually reproducing organisms, extending even to bacteria and viruses. In 1927 Muller perfected the measurement of spontaneous mutation which enabled him to prove the effect of temperature. It also enabled him to prove the effect of X-rays. Muller's method first made it possible to show that mutations had been induced, and that those, therefore, which were apparently 'spontaneous' might in fact be regarded as determined. It revolutionized genetic technique by providing an artificial source of variation in any organism where it was needed. It led to the discovery that chromosomes could be broken and recombined, first by ionizing radiations and later by chemical reagents, a discovery equally important in plant breeding and cancer research. This work put the study of genes, chromosomes and evolution on an experimental basis. In all the developments which followed, Muller has taken a leading part. Of the greatest importance have been his examination of the genes as units of physiological action and of X-ray breakage, his analysis of the physiological properties of different classes of mutations, his demonstration of the existence of 'inert' genes, and his physiological interpretation of Fisher's theory of dominance. Muller's discussions of the theory of genetics are no less significant than his experimental work. He first suggested the importance of chromosome balance in sex determination. He first (in 1918) showed how the mutations of *Oenothera*, on which De Vries's theory of evolution was based, could be regarded as due to Mendelian segregation, an explanation established in the following fifteen years. He first (in 1921) pointed out the analogy between virus and gene and its practical significance. Briefly, Muller's work and ideas, always in advance of the times, moulded the development of genetics in the critical years between 1916 and 1936, and it was in recognition of this achievement that he was awarded the Nobel Prize for Medicine in 1946.

## Directorship of the Meteorological Office: Sir Nelson Johnson, K.C.B.

THE Air Ministry has announced that Sir Nelson Johnson is to retire in the autumn from the post of director of the Meteorological Office. Sir Nelson received his scientific training at the Royal College of Science, London, joined the Meteorological Office in 1919 after war service as a pilot, and formed the new meteorological office at the War Office Chemical Defence Research Establishment at Porton in 1921. The investigation at Porton of the meteorology of the lower layers of the atmosphere gave full scope to his capacity for experimental research; he devoted himself especially to the vertical gradient of temperature, devised new methods for its measurement, and, in Geophysical Memoirs 46 and 77 of the Meteorological Office and elsewhere, he published work which has become classic in this field. He left the Meteorological Office in 1928 for service in the War Office, and in September 1938, on the retirement of Sir George Simpson, returned to the Meteorological Office as director. The Second World War brought a large expansion in the work and size of the Office and a corresponding increase in the director's responsibilities. In spite of a heavy load of day-to-day administration, Sir Nelson continued the planning, begun in 1938, of a new research organization for meteorology, and in 1941 the Air Ministry Meteorological Research Committee was set up. After the War he carried out a major reorganization of the Meteorological Office, including the setting-up of the planned research organization. In 1946, at the first post-war international conference on meteorology, he was elected president of the International Meteorological Committee, and in that capacity he presided over the Washington Conference of Directors in 1947, which established the Convention of the World Meteorological Organization; in 1951 he became the first president of the new Organization. Great progress in meteorological organization has been made under Sir Nelson's guidance and his services were recognized by the award of a K.C.B. All who have served under Sir Nelson, either in British meteorology or in the international field, will wish him good health during his retirement for many years to come so that he can actively pursue his many and varied interests.

## Prof. O. G. Sutton, C.B.E., F.R.S.

PROF. O. G. SUTTON, at present dean and Bashforth professor of mathematical physics in the Royal Military College of Science, Shrivenham, who has been appointed to succeed Sir Nelson Johnson, is an expert of world-wide authority in the dynamics of the lower atmosphere. He graduated in mathematics from the University College of Wales, Aberystwyth, and was a lecturer there before joining in 1928 the staff of the Meteorological Office. He was posted to Porton in 1929 and soon showed his powers by his work on the mathematical theory of turbulent diffusion in the atmosphere. In 1942 he was appointed superintendent of research in chemical defence at Porton, and during 1943–45 was superintendent of tank armament research. He went to the Radar Research and Development Establishment in 1945 as chief superintendent and in 1947 was appointed Bashforth professor in the Royal Military College of Science. He was scientific adviser to the Army Council in 1951, and is now chairman of the Atmospheric Pollution Research Committee of the Department of Scientific and Industrial Research, as well as serving on other meteorological committees. Prof. Sutton has written a large number of papers on the structure of the lower atmosphere and turbulent diffusion and their applications to such practical problems as evaporation from free water surfaces and the dispersion of smoke from factory chimneys. His recently published text-book, "Micrometeorology", is an exhaustive survey of knowledge on the atmosphere at breathing level. He was elected to the Royal Society in 1949 and awarded a C.B.E. in 1950.

## Royal Meteorological Society: Symons Memorial Medal Award

The Symons Memorial Gold Medal for 1953 of the Royal Meteorological Society has been awarded to Prof. Carl-Gustav Rossby, director of the Meteorological Institute, University of Stockholm, and lately professor of meteorology in the University of Chicago, in recognition of his outstanding contributions to meteorology. The citation states: "He has placed his permanent impress on the fundamental branches of the science from the small-scale turbulence of the lower atmosphere to the dynamics of the large-scale currents and their relation to the general circulation of the atmosphere. We esteem Professor Rossby most of all perhaps for the vigorous lead he has given to scientific meteorological research and for his inspiration and encouragement of meteorologists in all parts of the world".

## Diffusion of Knowledge

Speaking in Washington on February 13 at a dinner given in his honour, Dr. L. Carmichael, the incoming secretary of the Smithsonian Institution, referred to the tribute which had been paid by Americans on January 16, 1879, to the memory of the first secretary of the Institution, Joseph Henry, who had died eight months previously. That tribute to a great scientist was also a unique official tribute to science itself; but nevertheless Dr. Carmichael wondered whether any real progress has been made in the past seventy-five years in diffusing an understanding of science. In a farewell address to the American Philosophical Society in 1796, Washington had urged, as an object of primary importance, the promotion of institutions for the general diffusion of knowledge, adding that, in proportion as the structure of a government gave force to public opinion, it is essential that public opinion should be enlightened. James Smithson, in bequeathing his property to the United States of America for the founding of the Smithsonian Institution, defined it as "an establishment for the increase and diffusion of knowledge among men", and Andrew Carnegie, who for many years placed the motto "Let there be light" in all the libraries he established, is said to have believed that enlightenment is the one general remedy for the ills that beset the human race. Although pure and applied science to-day find unequalled public and private support in many sections of the nation, Dr. Carmichael believes it is still necessary to defend research expenditure by referring to the immediate practical utility of the investigations. We still need a society for propagating the understanding of the true place of science in society. The great human advantages which the world would derive through the proper support of science must be told and told again in clear and popular language. Washington, Smithson and Carnegie envisaged a happy marriage between research and public information, and Dr. Carmichael thinks that scientists should see that neither selfishness nor inertia prevents their participation in the task of interpreting science to the millions and assisting the expert science writers in a task to which they have already brought intelligence, enthusiasm and dedicated service.

## *Journal of Rational Mechanics and Analysis*

In the first four numbers of a new quarterly, the *Journal of Rational Mechanics and Analysis* (published by the Graduate Institute for Applied Mathematics, Indiana University, Bloomington, Ind.), there are, in all, some twenty papers running to about six hundred and fifty pages of print, and it is now possible to review the *Journal* during the first year of its existence. The editors are Profs. T. Y. Thomas and C. Truesdell, and the eminent editorial board, numbering twenty-six, is drawn in about equal proportions from United States universities and institutes of technology and from the corresponding institutions in various countries of western Europe. The purpose of the *Journal*, as stated on the inside front cover, is "to close the rift between 'pure' and 'applied' mathematics and to foster the discipline of mechanics as a deductive, mathematical science in the classical tradition. Its scope comprises those parts of pure mathematics or other theoretical sciences which contribute to mechanics; among the included fields are all branches of analysis, differential geometry, analytical dynamics, elasticity, fluid dynamics, plasticity, thermodynamics, relativity and statistical mechanics. Engineering applications, numerical work, perturbation procedures, etc., are acceptable only as incidental illustration in a paper devoted to sound mathematical theory". The papers published to date are fully consistent with this point of view, being primarily pure mathematical in character and outlook, and having the explanation of natural phenomena as but a secondary objective. In this respect, the *Journal* is in marked contrast to the *Quarterly Journal of Mechanics and Applied Mathematics* (Oxford University Press). That there is a place for the publication of papers of the kind just described is beyond doubt, but the extent of the interest which such papers are likely to arouse is open to question. With regard to subject-matter, there have so far been nine papers on fluid dynamics, three on elasticity or plasticity, one on relativity and one on analytical dynamics, while the remaining six have ranged over a wide variety of topics. The subscription price of the *Journal* is 6 dollars a volume for individuals engaged in research or teaching, but 18 dollars for everyone else; by British standards, the latter figure is distinctly high.

## Recruitment of Scientists and Technologists in Great Britain

In reply to a question in the House of Commons on April 28, the Chancellor of the Exchequer, Mr. R. A. Butler, stated that the number of scientists and technologists coming from the universities and technical colleges of Great Britain with degrees, Higher National Certificates and Higher National Diplomas, or their equivalent, during the academic year 1951–52 was estimated to be one in about 2,600 of the population. Mr. Butler added that the Government is doing its best to improve the facilities for technological education; he concurred with the suggestion that there is still great difficulty in persuading engineering and other firms to employ the scientists and technologists in the works, and that industry requires a great deal more encouragement to make use of the highest and best form of knowledge.

## A Model Rehabilitation and Training Centre

In May 1952 the President of the Austrian Republic performed the opening ceremony of what is probably the finest rehabilitation and training centre to be found in Europe. It is situated at Tobelbad, about nine miles from Graz, and has been built on the site of a former spa (*Rehabilitation*, 7; January 1953). Extensive new buildings have been erected over the site of the hot springs affording ample accommodation

for 250 patients as well as the staff of the centre. The centre is owned by the Allgemeinen Unfallversicherungsanstalt (United Accident Insurance Corporation). The Corporation's decision to establish this centre for the rehabilitation of accident cases occurring anywhere in Austria was largely influenced by the views of two young orthopædic surgeons who were members of the first rehabilitation course held in Great Britain under the auspices of the British Council. When completed, the training centre, which is directly connected to the rehabilitation centre, will be used for short courses of training in carpentry, metalwork, wood-carving, leather work, shoe-making, tailoring and dressmaking. It is not intended to use them for long or complete vocational training courses, such as are available in Government training centres, but rather as a means of giving both work therapy and vocational guidance to those undergoing physical and industrial rehabilitation before returning to their former employment or undertaking new courses of training.

## "The Behaviour of Engineering Structures"

PROF. A. J. S. PIPPARD writes: "In my article published in *Nature* of May 2, I made the statement that it was not until 1947 that exact theoretical solutions for the stresses in masonry dams had been obtained. It has since been pointed out to me that Dr. L. F. Richardson dealt with this subject in a paper entitled 'The Approximate Arithmetical Solution by Finite Differences of Physical Problems involving Differential Equations, with an Application to the Stresses in a Masonry Dam", published in *Phil. Trans.*, A, 210, 307 (1911). I regret that I overlooked this reference".

## Announcements

THE Alexander Pedler Lecture of the British Association is to be given this year by Sir Harold Hartley; he will speak on "The Life and Times of Sir Richard Gregory". The Lecture will be given in the Royal Institution on May 28 at 6 p.m.; applications for tickets should be sent to the Secretary, British Association, Burlington House, Piccadilly, London, W.1.

THE Council of the Royal Society of Edinburgh has awarded the Gunning Victoria Jubilee Prize for the period 1948–52 to Prof. A. C. Aitken, of the University of Edinburgh, for his distinguished contributions in the field of pure mathematics; and the Makdougall–Brisbane Prize for the period 1950–52 to Prof. E. M. Wright, of the University of Aberdeen, for his papers in the field of pure mathematics published within the period of the award in the Society's *Proceedings*. The Prizes will be presented by the president at the meeting of the Society on July 6.

DR. JOSEPH JUNKES, *S.J.*, has been appointed director of the Astrophysical Laboratory of the Vatican Observatory, in succession to Dr. Alois Gatterer; Dr. Ernest Salpeter, *S.J.*, is assistant director of the Laboratory. It is hoped that the first volume of the "Atlas of Molecular Spectra" ("Spectra of Diatomic Molecules, the Oxides"), undertaken by the Observatory at the request of the International Astronomical Union, on which Father Gatterer was engaged until shortly before his death, will be ready by the end of this year.

THE Royal Sanitary Institute, in collaboration with the Ministry of Agriculture and Fisheries (Infestation Control Division), is organizing a rodent control exhibition, open to the general public, to be held in the Institute's Museum of Hygiene, 90 Buckingham Palace Road, S.W.1, during May 26–June 20 (Monday–Friday, 10 a.m.–5 p.m.; Saturday, 10 a.m.–noon).

A SUMMER school in the use of electrons for the examination of metals will be held during July 20–31 in the Cavendish and Goldsmiths' Laboratories, University of Cambridge, in co-operation with the Institute of Metals. This will consist of lectures, demonstrations and practical classes in the principles of the electron microscope (including reflexion techniques) and electron diffraction camera and their practical applications to the study of metals. Application forms (to be returned by May 30) and further information can be obtained from G. F. Hickson, Secretary of the Board of Extra-Mural Studies, Stuart House, Cambridge.

Two interesting articles are contained in Vol. 1, Part 2 of the *Journal of the National Museum of Bloemfontein*. The first is by Dr. A. C. Hoffman and describes a dug-out canoe in use in Vendaland. It would seem to be the first of its kind to be found south of the Limpopo, and the first bark canoe to be described from southern Africa. The second article is by Dr. A. J. D. Meiring and describes some polished-edge bone implements found in the coastal strip from Great Brak River in the west to Matjes River in the east. The age may be Wilton.

THE summer provincial meeting of the Physica, Society will be held in the Department of Physics King's College, Newcastle upon Tyne 1, during July 13–14, the subject being optics and ultrasonics. The meeting will include visits to the Grubb–Parsons Optical Works and Pametrada Research Station. Hostel accommodation is available. The meeting is open to all on application to the offices of the Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

THE Present Question Conference this year will be on "Springs of Action" and will be held at Lady Margaret Hall, Oxford, during August 8–15. A number of lectures will be given in the mornings by leading experts, the subjects being tradition, the evidence of biology, politics, creative action, the longing for truth, knowledge, communication, moral judgment, productivity, leisure and personal decision. In the late afternoons and evenings, study groups and discussions will be held. The fee for the conference is 2 guineas (students 1 guinea). Accommodation is available in Lady Margaret Hall. Further information can be obtained from the Secretariat, Present Question Conference, 37 Middleway, London, N.W.11.

THE second British Plastics Exhibition and Convention will be held at Olympia, London, during June 8–18. The Exhibition will cover a wide range from the raw material to consumer goods, and more than eighty firms and organizations will be represented. The Convention is designed this year especially for the plastics technologist, and a comprehensive programme of papers has been drawn up by representatives of the British Plastics Federation, the Plastics Institute, the Society of Chemical Industry (Plastics and Polymer Group) and the journal *British Plastics*. The Convention is open to all, admission being by ticket only, obtainable from the organizers, British Plastics, Dorset House, Stamford Street, London, S.E.1.

# NUMERICAL METHODS AND AUTOMATIC COMPUTING IN ATOMIC THEORY

A SYMPOSIUM on the application of automatic computing machines to the problems of extra-nuclear atomic theory was held in the University Mathematical Laboratory, Cambridge, on December 9 last. The subject was introduced by Prof. D. R. Hartree (Cavendish Laboratory, Cambridge), who began by pointing out that problems in this field are usually concerned with the solution of Schrödinger's equation, $H\Psi = E\Psi$, subject to appropriate boundary conditions. For many-electron systems it is necessary to resort to approximation in attempting to obtain solutions of this equation. Two important classes of problem are those of an electron in a bound state and in a free state: the former is characterized by $E$ being negative and assuming a discrete, unknown value corresponding to each bound state; in the latter problem, $E$ is positive and known for the phenomenon being studied, such as elastic or inelastic collision of an electron with an atomic system. Prof. Hartree continued with a more detailed account of the solution of the stationary-state equation for complex atoms along the lines of a previous paper of his (*Rep. Progr. Phys.*, **9**; 1946–47). In particular, he outlined the defects of the Slater–Fock approximations in failing to express correlations between the positions of individual electrons in an atomic structure, and possible means of including, in the approximate wave-function adopted, terms expressing these correlations.

This introduction was followed by an account by A. S. Douglas (Mathematical Laboratory, Cambridge) of some recent work on improved approximations to stationary-state solutions using electronic computers. For the class of configurations consisting of a 'core' of closed shells of electrons and a single series electron, the Hartree–Slater–Fock approximation for the wave function of the series electron can be improved by including a polarization potential term in the equations. It is possible to determine by trial an empirical addition to the potential function in such a way as to bring the calculated energies of all terms of the optical spectrum into close agreement with the observed values; the agreement with experiment does not define the additional potential function uniquely. This has been done for $Si^{+3}$, using the EDSAC to compute the integrals involved in treating the additional potential as a first-order perturbation, and also to solve directly the equation, with exchange, including the additional contribution to the potential. The Runge–Kutta step-by-step method of integration developed by Gill for use on the EDSAC has been adapted for this purpose. An empirical rule for determining the additional potential for other structures has been postulated and is now being tested for $Ca^{+}$.

A second problem investigated by Mr. Douglas concerns the computation of an approximate wave-function for two-electron structures, such as helium, in the ground-state. Schrödinger's equation for helium can be reduced to a partial differential equation in three variables, and this can be solved approximately by solving a related parabolic equation involving an auxiliary independent variable $t$, the solution of which tends asymptotically to the required function as $t$ increases. The related equation can be replaced by its finite difference form and solved step by step in $t$. Exploratory work on the equation for the stationary states of hydrogen by this method indicates that a large number of steps in $t$ may be required, and has disclosed some anomalies in the process of convergence, which are under investigation.

In the afternoon, Dr. R. A. Buckingham (University College, London) gave an account of the use of variational methods of solving two-body and three-body collision problems. For slow electrons the only important contribution to the cross-section for elastic scattering is dependent on the asymptotic phase of the scattered electron. It can be shown that for small, restricted variations of the wave function, this phase is stationary, and this can be used for determining an approximation to the phase by one of the variational methods devised by Hulthén (1944) or Kohn (1948). These methods both involve solution of sets of simultaneous algebraic equations, those of Hulthén's method being quadratic, and those of Kohn's method being linear.

Even comparatively simple approximations to the wave functions for inelastic scattering lead to the necessity for solution of two simultaneous integro-differential equations. Such equations can be solved by the 'distorted wave' method used by Erskine and Massey (1952) in studying the inelastic scattering by hydrogen. Moiseiwitsch (1952) has shown that a variational method of solution is possible, and a finite difference method is at present under investigation. The application of electronic computers to the last two methods is likely to be of special value, in view of the very lengthy computations required. It is interesting that all these procedures have been successfully used in treating collisions between simple nuclei, such as the scattering of neutrons by protons, which have been studied by Swan (1952).

After a short discussion of Dr. Buckingham's paper, Dr. V. E. Price (Department of Theoretical Chemistry, Cambridge) described the use of the EDSAC to compute atomic wave-functions by the variational method due to S. F. Boys (1950–52). The required wave-function is considered expanded as a linear combination of 'serial products' of a complete set of chosen functions, the coefficients of the expansion being determined by use of the variational principle. For stationary-state solutions, the energy-levels are the eigenvalues of a matrix, the elements of which are found by evaluating certain integrals. Each one of these integrals contains not more than four members of the set of functions, and can be evaluated from a recurrence relation, provided a suitable set of functions is chosen. On the EDSAC such an evaluation takes about four seconds. To find the matrix elements from the integrals requires considerable algebraic manipulation, such as matrix multiplication, which can also be done on the machine. The eigenvalues of the resulting matrix, too, can be found by the machine. By taking a sufficiently large matrix, it is possible, in principle, to obtain any required accuracy for the solutions. This is not practicable, however, and it is necessary

to choose the few particular members of the set of functions included in the calculation so that a good approximation is assured. A relatively simple calculation can be made to test the probable importance of omitted terms. Calculations on this principle have been carried out on a number of atoms and ions, including chlorine and sulphur, for which thirteen functions were used.

In the ensuing discussion, Dr. Boys (Cambridge) pointed out that the method used can be extended to find molecular wave-functions, the integral evaluation technique being largely applicable to this problem also. In reply to questions by Prof. Hartree and Dr. O. Bunemann (Cambridge), Dr. Boys said that the method is not likely to be of assistance in the nuclear field at present, since the accurate equations are not known with certainty. In answer to Dr. Buckingham, he said that electron affinities calculated by the method have so far shown disappointing lack of agreement with experiment.

After tea, two short contributions were given by visitors. Mr. W. A. Runciman (General Electric Co., Ltd., Wembley) described a problem connected with the fluorescence of a structure consisting of a potassium chloride lattice, in which some of the potassium ions are replaced by thallium. A first approximation to solution of this problem can be obtained by assuming the thallium ions to be in a free state, and an approximate evaluation of the wave functions by the self-consistent field method has been carried out on the EDSAC.

The final contributor was Dr. R. H. Garstang (University College, London), who mentioned a problem he had met in the analysis of departures from Russell–Saunders coupling; this involved the determination of the diagonal elements of a matrix, given its non-diagonal elements and its characteristic values.

A. S. Douglas

## PHYSICAL FACTORS IN RELATION TO BIOLOGICAL ACTIVITY OF INSECTICIDES

A MEETING of the Crop Protection Panel of the Agriculture Group of the Society of Chemical Industry was held in the rooms of the Chemical Society in London on February 16, when papers on "Physical Factors in Relation to Biological Activity of Insecticides" were read. Dr. R. A. E. Galley was in the chair.

Mr. C. T. Lewis (Imperial College of Science and Technology, London) discussed factors affecting the adhesion of dry particles of uniform size to active insects. Experiments with selected dyestuffs have shown that dry lipoid-soluble particles adhere more readily to the cuticle of blowflies, and to leaf wax, than do lipoid-insoluble particles possessing polar groups. Presumably the presence of polar groups lessens the attraction at the solid–solid interface due to Van der Waals forces. The phenomenon has an appreciable influence on the rate of accumulation of particles by flies exposed to deposits. Parallel experiments with insecticidal dusts have yet to be performed; but significant effects may reasonably be expected since contact insecticides are lipoid-soluble and most diluent dusts are calcium or magnesium silicates.

Mr. Lewis also considered the effect of the 'cleaning' reactions of a treated fly on the retention and location of accumulated particles. Particles are picked up from a surface on ventral tarsal spines and chemoreceptors, and transferred in cleaning movements to less exposed parts of the body. The frequent cleaning movements result in a balance between the weights of particles at different locations, the head at all times retaining about 7 per cent of the total, the legs 48 per cent, the wings 13 per cent and the abdomen 28 per cent. The pulvilli are not important sites of accumulation, retaining about 2 per cent, and experiments have shown that they are not preferred sites of entry of DDT.

The rate at which fine particles are discarded by a contaminated fly depends largely on the rate at which the continued cleaning movements deliver particles back to the tarsal spines, from which they are returned to the substrate. The rate of loss is rapid until the quantity retained by the fly falls to 20 μgm., but is very slow below 10 μgm.

Dr. A. H. McIntosh (Rothamsted Experimental Station) dealt with the effect of certain conditions of test on the toxicity of a single insecticide, illustrated by reference to experiments in which insects were treated by dipping in aqueous suspensions of DDT. The weight retained depends upon the particle size, being greater for needle-shaped crystals than for colloidal particles. Temperature has a notable effect on toxicity, and the temperature coefficient, usually negative, varies with particle size and with humidity. High humidities accentuate the difference between the temperature coefficients of large and small particles.

The fact that poisons do not always have the same speed of action is an additional complication. The values obtained in relative toxicity tests may vary with the time at which observations of kill are made.

Dr. McIntosh also discussed the relation between the contact toxicity of insecticides and their fat-solubility. The first stage in the entry of a contact insecticide is assumed to be solution in the wax layer, and it is often implied that the higher the lipoid-solubility the more effective the poison is likely to be. An opposite conclusion can be deduced from Ferguson's principle of drug action, which indicates that different compounds have equal biological activity if applied at the same percentage saturation in the surrounding medium. Dr. McIntosh suggested that if this idea applied to the wax surrounding an insect, compounds of low fat-solubility should be the more effective. He pointed out, however, that there is no relation between the absolute toxicity of DDT and its analogues and lipoid-solubility. The view now held is that some degree of lipoid-solubility is necessary but it need not be high.

Experiments still in progress lead Dr. McIntosh to conclude that the difference in speed of action between colloid particles and crystals for a range of compounds of the DDT type may be related to the rate of solution of crystals in oil *in vitro*.

Dr. F. Barlow (Colonial Insecticide Research Unit, Porton) enumerated and discussed some factors of importance in the control of adult mosquitoes by residual spraying of houses. Mosquitoes are stimulated to flight after a short time in contact with insecticidal surfaces, and this fact increases the importance of physical factors affecting the availability of deposits.

The best formulation for deposits on absorbent walls is a wettable powder; the dispersing medium

is absorbed, leaving insecticide particles freely exposed. On all types of surface, toxicity is inversely related to size of particle, because smaller particles are more easily picked up and retained by insects.

Dr. Barlow then dealt with factors affecting the persistence of deposits on various types of surface. Volatile insecticides exhibit decreasing residual action for a range of substrates from non-absorbent to absorbent. Increasing rates of evaporation and sorption into the substrate are responsible. Loss of insecticide has been found to be extremely rapid on certain adsorptive substrates and is due almost entirely to sorption; for example, on mud-blocks prepared from lateritic earths used for hut-building in several tropical countries.

Insecticides possessing fumigant action, for example, BHC and 'Aldrin', are effective for long periods after sorption, but others are ineffective after sorption, for example, DDT and 'Dieldrin'.

Finally, Dr. Barlow considered residual deposits of oil solutions. These deposits can be employed on non-absorbent surfaces, when formulations which do not crystallize are to be preferred because the recumbent crystals produced on such surfaces are not readily picked up by insects. By way of contrast, on fibrous absorbent surfaces, oil solutions are not available at first; but after crystallization has occurred the crystals project from the superficial fibres and are readily detached by insects.

Opening the discussion, Dr. A. B. P. Page observed that all three speakers had dealt with rate-determining processes. While there are big differences between fumigation and contact action, in each process accumulation and penetration of the toxicant are continuously occurring alongside toxification and detoxification within the insect. With fumigants, one measure of toxicity is the product of the concentration of the fumigant multiplied by the period of fumigation. In the same way the toxicity of a contact poison may be expected to be some integral function of the net amount of toxicant on the insect and the period of contact.

In certain fumigations a better measure of toxicity appears to be the amount of fumigant sorbed by the insects, and this relation implies dependence of toxicity on the shape of the concentration–time curve as well as on the area under it. An analogous relation may be found for contact poisons where large amounts of insecticide accumulated initially by the insect may greatly influence toxicity despite their rapid removal by cleaning movements.

Dr. Page remarked that Dr. McIntosh had concerned himself with the solubility of poisons in the epicuticular wax layer, but had not mentioned the possibility of preferred sites of diffusion through the cuticle and access to specific sites of action. Such considerations are important. Referring to Dr. Barlow's account of the fumigant action of certain solid insecticides absorbed into porous substrates, he recalled an analogous case of absorption in bagged stored products treated with an insecticidal dust; wheat, for example, can absorb enough DDT in the seed coats to enable the insecticide to act as a contact and stomach poison, whereas with BHC the fumigant action is all-important.

In reply to a question from Dr. J. R. Booer, Dr. McIntosh said that his colloidal suspensions were prepared in a standard way but he had not measured the size of particle.

Dr. J. C. McGowan pointed out that Ferguson's theory cannot be related to the system described by Dr. McIntosh. If insects are treated with aqueous solutions of insecticide, then the theory can be used; but the solubility of DDT in water is so low that a lethal dose cannot be applied by such a method. Mr. G. F. H. Whitney observed that Ferguson's theory applies to substances showing 'physical' toxicity; a substance showing a toxicity greater than that expected by the application of Ferguson's theory invokes 'chemical' toxicity. Dr. McIntosh commented that he had not stated that Ferguson's theory is valueless, but that it is not useful in the case of DDT and its analogues. In answer to Mr. P. S. Hewlett, he agreed that he considers the action of DDT to be physical.

Mr. F. H. Rae asked whether Dr. Barlow advocated whitewashing huts before spraying, which he considered would not be a practicable procedure. Was sodium silicate useful and could Dr. Barlow suggest any other substance which might reduce losses due to sorption? Dr. Barlow said that the ideal would be to incorporate a substance in the spray which would block the capillary spaces in the substrate and thus reduce sorption. Size is not suitable for tropical use. The problem is being studied; but he had no practical recommendations to make at present.

Mr. P. Bracey asked if it is known whether BHC in the vapour phase enters an insect through the integument or through the spiracles; Dr. Page thought that no information is available.

Closing the discussion, Mr. W. H. Read stressed the practical importance of work in this field.

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## THE PLACE OF UNIVERSITY GRADUATES IN INDUSTRY

TWO most interesting points are featured in the report of the Universities and Industry Conference, organized by the Federation of British Industries and by the Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom, and held at Ashorne Hill during October 24–26, 1952*: the first is the further support which is forthcoming for the argument advanced in the last report from the Advisory Council for Scientific Policy that a new attitude towards industry and technology is desirable on the part of the schools and the universities; and the second is the large measure of agreement in addresses and discussions to the effect that, in consequence of the large proportion of talent which is now entering the universities, industry must necessarily rely to a much greater extent on recruitment from the universities to provide its future leaders (its chances of recruiting the requisite ability from those leaving school direct has been greatly diminished). The published report contains the addresses by the following: Sir John Maud on the use of the university graduate in the Civil Service and the qualities of the graduate which have proved most useful; Sir Ewart Smith on the qualities industry requires in the university graduate and his role in industry; Dr. Eric Ashby on the ability of the universities, consistently with their other obligations, to turn out men with the qualities required by industry; and

* Report of the Universities and Industry Conference, organized by the Federation of British Industries and the Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom, and held at Ashorne Hill, Leamington Spa, 24–26 October, 1952. Pp. 87. (London: F.B.I., 1953.) 5s.

Mr. A. D. Bonham-Carter, Mr. Ralph Colman and Mr. A. G. Grant on industry's use of the university graduate. Also included are Sir Robert Wood's reflexions on the conference at its final session, and a summary of the main points which emerged, by Sir Norman Kipping, Dr. C. R. Morris and Mr. D. R. O. Thomas.

Sir John Maud, in a very frank and stimulating address, made it clear that the Civil Service is looking for essentially the same qualities of integrity, courage, readiness to work, straight and original thinking and the capacity to make up one's mind as is sought by industry; nevertheless, he thought, while the Civil Service requires a larger proportion of first-class graduates than it has been receiving, it is of importance to the national interest that, during the next ten years at any rate, the claims of industry for first-rate men should receive priority. It is a matter of national importance that the university graduate should come to regard industry and commerce not merely as careers which offer a reasonable chance of a livelihood and of satisfying ambitions but also as opportunities of doing something in the nature of service in which they can take pride. Sir John earlier in his address had commented pointedly on some of the objectionable qualities to be found in the university graduate—qualities such as bad manners, inaudibility, and excessive specialization, which are not by any means limited to those who elect to enter the Civil Service.

Sir Ewart Smith likewise referred to the importance of influencing the general climate of opinion with regard to industry. He thought that wider recognition of the teaching of administrative studies in the universities would help to this end as well as to improve the quality of future management, but the idea that management should be taught in the universities found little support from him or other industrial representatives present, apart from Mr. N. G. McCulloch. The idea that management is a technology or a fit subject for university teaching was rejected forthright by Mr. A. G. Grant and Dr. Ashby, and Sir Ewart clearly voiced the general opinion of industrial representatives in his view that the first requirement is for men and women who have been trained to think, to understand, to be critical and to show initiative, and who have some understanding of wider aspects of life than can be gathered from one particular discipline. He thought that this wide outlook and capacity to think can be acquired through technology or science, as well as through the arts, if the subjects are properly taught, and at present, as Prof. J. A. L. Matheson reminded the Conference, the technological departments are not getting their fair share of first-class brains.

Dr. Ashby's address supplied the quantitative basis for the argument that industry must rely increasingly on the universities for its recruits for management. While, since 1912, the reservoir of persons eighteen years old has decreased by 74,000, the number from the reservoir who have entered universities has increased by 12,537, and during 1951 73 per cent of university students were receiving financial aid, mostly from public funds. The barrier to university education is now largely intellectual, not financial, and it is becoming difficult for a reasonably bright boy who remains at school to avoid going to a university. Already the universities are taking as much as a third or more of the educated high talent in the reservoir and may well take more as the machinery for separation becomes more efficient. This position makes it essential, continued Dr. Ashby, that the universities should discover the needs of industry; but he urged that industry should itself do much more to make known both its needs and its opportunities and to further a better understanding of the true purpose of industry, of its vital importance to the nation, and of the interest and satisfaction that it can offer to those who serve in its higher ranks.

That industry should do much more to explain its nature and purpose to the nation, and to persuade potential entrants that it provides a purposeful career with manifold opportunities for using good brains in essential work, was a main point which emerged at the Conference. This task should begin with the schools and the universities by publishing well-written literature designed to stimulate the imagination of young persons. The proportion of the ablest grammar-school boys who go to the universities has continued to increase, but the increase in the university population has not led to a corresponding increase in the number of men obtaining first-class honours degrees. Accordingly, even if industry were to recruit its due proportion of high ability of this kind, it might still fall short of its requirements, since the nation's total needs must be met from this strictly limited supply. This necessitates the fullest use being made of those with high ability wherever they are employed, and opinion was expressed that neither industry nor the Civil Service is yet making the best use of the specialist graduates it recruits.

Much remains to be done to broaden the education of the university graduate, and it is as clear from this conference as from the regional conference at Nottingham during the previous month that industry is critical of excessive specialization in first-degree courses and looks, above all, for those qualities on which Sir John Maud and Sir Ewart Smith laid emphasis. There is no evidence of a desire to stipulate a particular content of university education or, as already noted, to advocate the teaching of administrative studies at the undergraduate level. The universities would make their most effective contribution in the broader educational field by helping industry to continue the education and training of the graduates and men of equal ability it recruits. Reference was made to several experimental courses designed jointly by industry and the universities for men of this type who have been several years in industry and are twenty-five to thirty years of age. It was also noted that there has been no great industrial support for the postgraduate courses in technology which the universities have organized in response to a request made by industrialists at the conference held in 1949.

One further point needs to be emphasized by industry in its approach to the schools and universities regarding careers in industry. Although industry requires more men of high ability, the opportunities it can offer graduates are not unlimited. For most technical industries it is estimated that 4 per cent of the total employees fill scientific, administrative and management posts for which a graduate could appropriately compete. Only a few graduates could hope to reach the highest positions; but industry requires many more good men for the tasks of middle management, and these offer a full and interesting life. In this connexion the three papers on industry's use of the graduate led to a discussion in which Prof. A. R. J. P. Ubbelohde,

supported by others, stressed the need for more quantitative information about industry's intake of arts or non-specialist graduates as compared with the intake of specialists of all kinds, the average industrial life of the graduate in any one firm, and the migration of specialists to non-specialist occupations in industry. Information of this kind would go far to assist in dealing with the problem presented by the arts graduate, particularly if, as suggested by Prof. H. S. Kirkcaldy, the arts graduate avoids specialization and acquires the ability to make intelligent use of experts.

## SARDINE FISHERY OF CALIFORNIA

THE fishery for sardines, *Sardinops cærulea*, is a major industry in California; but there was a disastrous failure of the fishery during the 1947–48 season, and, although slight improvements have taken place in succeeding years, there seems at present little hope of a major recovery before the 1954–55 season at the very earliest. The area of profitable fishing has contracted to the region of southern California, resulting in extensive land transport of fish from there to the processing plants at Monterey and San Francisco.

As an emergency remedial measure the Sardine Industry Advisory Committee introduced a temporary programme of control and management for the 1948–49 season, but this proved unsuccessful and was dropped. Resulting largely from the undiminished initiative of the industry itself, a co-ordinated programme of sardine research by five scientific bodies has been brought into being. The agencies concerned are the California Academy of Sciences, the California Department of Fish and Game, the Stanford University (Hopkins) Marine Station, the United States Fish and Wildlife Service and the University of California (Scripps) Institute of Oceanography.

A progress report covering the period January 1, 1951–June 30, 1952, has recently been published*. The picture that emerges from the work to date is not encouraging. The fish population appears to be so reduced, and the possibility of significant recruitment of young fish so small, that unless the factor of availability operates to increase the normal catch of older fish, the sardine fishery must expect for at least another two seasons the smallest catches for a generation.

Data upon eggs and larvæ, young fish, food and feeding, growth- and mortality-rates, behaviour, schooling patterns and oceanographical conditions are being collected as rapidly as conditions allow—but long-term forecasting is not yet possible.

This important programme of co-ordinated research upon a vast and baffling problem is financed in part by funds from the industry in the form of a tax on landings, in part by a grant from the Federal Government and in part by a grant from the State of California, which makes the largest contribution.

The appearance of further reports on this very ambitious programme is awaited with keen interest, for it represents one of the most intensive combined assaults upon marine biological problems that has anywhere yet been made.

* California Cooperative Sardine Research Program. Progress Report 1 January, 1951, to 30 June, 1952. Pp. 51. (Marine Research Committee of the State of California Department of Fish and Game, 1952.) n.p.

## OVERSEAS FOOD CORPORATION

### REPORT FOR THE YEAR 1951–52

THE annual report of the Overseas Food Corporation for the year ended March 31, 1952*, differs in form from previous reports. Throughout the year the Corporation had been engaged in implementing the terms of the White Paper issued in January 1951, involving the running down of the vast organization built up for the mechanized production of groundnuts in East Africa, and also in an attempt to establish the economics of clearing and mechanized, or partly mechanized, agriculture under tropical conditions. The Corporation is thus now engaged in a large agricultural experiment, and, apart from the chapters on policy, organization and finance, respectively, the bulk of the report deals with the agricultural experiments in the three regions; the chapter on the work of the scientific department is likewise presented on a regional basis. The run-down in the Kongwa area is described in a separate report, appended to the main report, as are the accounts for the year.

The running-down operation has been effected with marked success and without serious detriment to the agricultural work. By March 31, 1952, the Corporation had handed over to the East African Stores Disposal Board about 80 per cent of its surplus stores and equipment, while transfer of the surplus fixed capital assets was virtually complete. The reduction of the European staff by 50 per cent to 636 and of the non-European staff by 18 per cent, giving a ratio of Europeans to non-Europeans of 1 : 23 in place of 1 : 14, proceeded smoothly, and a high proportion of Europeans leaving the service of the Corporation found satisfactory alternative posts in East and Central Africa. The London office has been reduced to a small agency, the Nairobi agency closed, and the Dar-es-Salaam agency incorporated with the general headquarters administration, which moved to Dar-es-Salaam during November 1951. Each region is now administered by a general manager, directly responsible to the chairman in his capacity as chief executive. With the exception of the chief health adviser, who was due to leave in July 1952, the technical advisers had already left the Corporation.

Decentralization of the engineering services is complete, and decentralization of the health department was to be completed when the chief health officer left in July 1952, by which date a reduction in European staff to 38 from the 85 at March 31, 1951, was envisaged. In this final report on health services the opinion is recorded that the danger to the health of Europeans in this area was much exaggerated, and the hospital bed planning figure, originally 2 per cent of the population entitled to treatment, has been reduced to 1 per cent and is being further reduced. The most effective measure for adult mosquito control has proved to be spraying all buildings with 'Gammexane' at three-monthly intervals, and this is now compulsory in Urambo and Nachingwea. Malaria is the commonest disease affecting Europeans, and, although 'Paludrine' has not been used either as a prophylactic or for treating Africans, there is evidence of the emergence of 'Paludrine'-resistant strains of the malaria parasite.

* Overseas Food Corporation. Annual Report and Statement of Accounts for the Year ended 31st March, 1952. Pp. iv+110. (London: H.M.S.O., 1953.) 3s. 6d. net.

The run-down of Kongwa, which has now been divided into four separate farms with a total area under crop of about twelve thousand acres, presented special problems as this small area could not support economically the large installations built up to support both a large executive headquarters and three agricultural units each of thirty thousand acres. An administrator was appointed to run-down Kongwa and provide all the necessary services for the farms until they could be made self-sufficient. Kongwa has been declared a township by the Tanganyika Government, and on October 1, 1951, the Public Works Department assumed responsibility for the supply of water and electricity and the maintenance of roads. A small hospital has been retained and receives some contribution to its upkeep from the Tanganyika Government.

Although promising results have been obtained on the Kongwa farms since the Kongwa Working Party reported, experiments must continue for at least one or two seasons before conclusions can be drawn. Nevertheless, there are grounds for believing that a rotation in which groundnuts play an important part can be found. It is also evident that the estimated crop yields in both the Southern Province and in Urambo, especially in respect of the groundnuts, which is the main crop, cannot be obtained until much more is learned of the basic agricultural principles to be applied in these difficult areas. Groundnuts appear to be unlikely to play an important part in any rotation for these two areas, at least for several years to come, and accordingly the Board has recommended the slowing-down of the tempo of its operations in both these regions until the economics of the agricultural practices are fully established. Alternative cash crops, which have already stood the test of two seasons, are promising; and provided that due caution is exercised, it is anticipated that an agricultural pattern will be evolved and a mass of data accumulated which will make a real contribution to the development of these previously uninhabited areas in Africa.

In the Kongwa farms, yields per acre for the 1950–51 season averaged 367 lb. for groundnuts, 1,750 lb. for maize and 1,070 lb. for sorghum, and the experience gained during the season indicated that groundnuts should be given priority over maize in the planting programme. Although all seed was treated with 'Agrosan', collar rot (*Aspergillus niger*) caused considerable seed-bed losses in nuts during periods of dry weather and long periods of wet weather: in trial plantings 'Fernasan' seemed to give better control over collar rot. While trials with giant castor indicated that a fair yield can be expected in almost any season, there is room for considerable plant-breeding work for standardization in size of seed, time of maturing, etc., while it appears that hibiscus seed can be treated successfully to improve germination.

In the Urambo area yields per acre for the season averaged 404 lb. for groundnuts, 1,132 lb. for maize, 557 lb. for sorghum, 512 lb. for sunflower, 504 lb. for soya bean, 53 lb. for dwarf beans, 395 lb. for tobacco and 3,363 lb. for an experimental crop of rice grown by the scientific department. Sleeping sickness constitutes a constant threat, although no further cases were discovered, and the elimination and control of *Glossina morsitans* is a problem of the greatest importance, demanding much further research. A technical committee formed to deal with tsetse control in the area has recommended an approach to the Secretary of State for the Colonies, the East African High Commission and the Government of Tanganyika with the view of formulating and financing a research scheme.

In the Nachingwea area the average yields per acre of the two main crops were 756 lb. of groundnuts (in shell) and 1,053 lb. of maize; but the results from the cotton crop were unsatisfactory, due probably to late planting and the use of an unsuitable variety. Endeavours are being made to obtain varieties of soya beans suited to the local environment and fit for combine harvesting. Good yields were obtained from different varieties of millet, especially golden millet.

Soil fertility studies by the scientific department in the Kongwa region during 1950–51 were almost wholly concerned with the yellow sandy loams of the Mtanana series. Limestone in exploratory experiments with maize gave a mean increase of yield of 280 lb. per acre, and phosphate and lime applied together were the only first-year treatments which raised the yield of maize in the second year. Other experiments were carried out on soil of the Chamaye series to measure the effect of superphosphate, applied to four different crops in the first year, on the yield of groundnuts in the second year and to determine the residual value of eleven different phosphatic fertilizers. Experimental crop studies include trials of different varieties of groundnuts and of the effects of different dates of harvesting, as well as trials of dwarf and semi-dwarf sorghums, Kenya yellow maize, varieties of safflower and dwarf Hungarian castor. Many organic and metallic compounds were tested as seed dressings for groundnuts, and a detailed experiment showed that seed which has been damaged in the slightest degree may fail to germinate. Lesions of *Cercospora personata* were only found where the disease assumed serious proportions; but it is suspected that viable spores can persist in crop residues and in the ground, and a residue disposal trial was laid down. Infestation of sorghum by stem borers caused considerable losses, and *Calidu dregei* was also a major pest of sorghum.

In the Urambo region pronounced pedological changes have occurred during the past three years. Accumulation of rainwater in the soils through the complete removal of the natural vegetation has rendered a considerable proportion of the sandy soils unsuitable for mechanized production of arable crops, while there have been heavy losses in reserves of soil nitrogen through the rapid mineralization of organic residues from the woodlands by microbiological activity and subsequent intensive leachings by heavy rains. Soil fertility studies were confined to groundnuts, maize and tobacco. Early planting and the eradication of volunteer groundnuts in the dry season are at the moment the only means in the control of rosette of groundnuts. Stemborer may become a major pest of maize, and infestation of sorghum is also serious. A survey of three thousand acres of groundnuts in the Nachingwea region showed that an average of 3 per cent was rosetted, and a single spraying with 0·5 per cent of a systemic insecticide at 40 gallons per acre appreciably reduced the incidence of the disease. Much attention was given to a study of the biology of the insect vector of the disease. Trials of the effect of two seed dressings on groundnuts suggest that hand-picking of seed before treatment would improve the plant stand. Further evidence has been obtained that the soils in the Southern Province are, in general, deficient in phosphates.

# ANALYSIS OF ENVIRONMENTAL VARIABILITY IN QUANTITATIVE INHERITANCE

By E. C. R. REEVE and F. W. ROBERTSON
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A LARGE fraction of the phenotypic variance of most quantitative characters is of environmental origin, even in populations maintained under carefully standardized conditions; but the nature of this non-genetic variability has received little attention, although it raises problems of fundamental importance in phenogenetics, particularly as the extent of variability may be very different for different genotypes[1]. The concentration of interest on genetic variations can be traced partly to the fact that statistical ideas borrowed from other fields have led geneticists to think of the environmental variance too much as an 'error variance'—a box into which all unexplained sources of variation can be conveniently dropped. The environmental variance is also difficult to study experimentally, since the factors responsible cannot usually be either controlled or measured, except when we are comparing two different environments. Some information can be gained about the nature of the variability within a single environment by examining the environmental correlations between different characters, and we shall illustrate this method of approach with two examples from *Drosophila melanogaster*, cultured under the conditions described previously[2], which appear to reduce non-genetic variability to a minimum.

Wing- and thorax-length both show a much lower variance in heterozygotes than in homozygotes[1], and we may ask how far this is due to differences in the effects of factors acting on both characters or on one alone. The common part of their variance may be taken as a measure of the variance of body-size, while the independent variations of each will be the result of errors of measurement, asymmetry of the two wings (one only is usually measured), and environmental factors acting on one character only. The problem can be given a simple statistical formulation, since both characters have about the same coefficient of variation in inbred lines, although the wings are twice as long as the thorax. We can therefore write (using percentage or logarithmic units) $w = c + i_w$ and $t = c + i_t$, for the two dimensions of any individual. $c$, $i_w$ and $i_t$ are uncorrelated variables measuring common ($c$) and independent ($i$) variations from the population means, and $i_w$ and $i_t$ have the same variance ($\sigma_i^2$). Then, for a population of given genotype:

$$\sigma_w^2 = \sigma_t^2 = \sigma_c^2 + \sigma_i^2 = \sigma^2 \text{ (say)}$$
$$\text{covariance } (wt) = \sigma_c^2.$$

In practice, $\sigma^2$ can be estimated as $\sigma_w\sigma_t$, so that the correlation between wing- and thorax-length is $\sigma_c^2/\sigma^2$, that is, the fraction of the variance due to common causes. This formulation allows us to compare the actual components of variance in inbred lines and their crosses. Table 1 gives the estimates obtained from two tests, the variances being expressed as squared coefficients of variation.

In both tests, the main cause of the reduced total variance in the crosses is the sharp drop in $\sigma_c^2$. The variance of body-size is actually more than twice as great in homozygotes as in heterozygotes, and the magnitude of the difference is under-estimated in comparisons using only one character, since there is a much smaller change in the independent variance ($\sigma_i^2$) than in $\sigma_c^2$. Errors of measurement have been found to cause only a small fraction of $\sigma_i^2$, so that environmental variables affecting only one character appear to differ less in their effects on homozygotes and heterozygotes than do those with general effects on body-size. As a result, the correlation between wing- and thorax-length is much less in the heterozygotes.

Table 1. Components of Environmental Variance in Inbred Lines and their Crosses (Females)

| Comparison | | Nature of variance $\sigma_c^2$ | $\sigma_i^2$ | $\sigma^2$ | Correlation coefficient |
|---|---|---|---|---|---|
| *A* | Pure lines | 1·15 | 0·75 | 1·90 | 0·61 |
| | Crosses | 0·40 | 0·69 | 1·09 | 0·37 |
| *B* | Pure lines | 1·27 | 1·24 | 2·51 | 0·51 |
| | Crosses | 0·54 | 0·99 | 1·53 | 0·35 |

*A*, cross of two unselected lines; *B*, three crosses involving lines selected for small size

A different case is provided by the number of chætæ on the abdominal sternites of *Drosophila*, a character well known from the genetical work of Mather and his associates[3]. Males have three segments (No. 3–5) and females four segments (No. 3–6) with roughly equal numbers of sternal chætæ (typically about 20 and 25 in the two sexes). We thus have a serially repeated character in each individual, and it is of particular interest to examine the environmental correlations between the different segments.

One might expect both genetic and environmental effects to cause highly correlated variations of chæta-number on all sternites; and progeny tests on two wild stocks (to be described elsewhere) have shown that the genetical correlation between any pair of segments is close to unity. This means that gene differences mainly affect the general level of chæta production on all sternites and cause little or no local variations, so that one could expect little progress from selecting two segments in opposite directions. The environmental correlations have been estimated from nine inbred lines, each of which provides three correlations between pairs of segments in males and six in females, and the average correlations are given in Table 2.

Table 2. Environmental Correlations for Chæta-Number on Abdominal Sternites

| | Adjacent segments | Non-adjacent segments | Average |
|---|---|---|---|
| Males | 0·075 | 0·087 | 0·079 ± 0·032 |
| Females | 0·050 | 0·063 | 0·056 ± 0·031 |

Adjacent segments are no more highly correlated than non-adjacent segments, and the average for all pairs of segments in both sexes is + 0·068 ± 0·022, a value in striking contrast to the high genetic correlations found (0·9–1·0). There is, in fact, virtually no non-genetic correlation, so that environmental variations must be extremely localized in effect. The non-genetic variability is, nevertheless, quite substantial, since the coefficient of variation for individual segments is about 8 per cent.

Another peculiarity of the variations of chæta is that the number of abdominal chætæ is extremely resistant to changes of environment, such as quality and quantity of food, humidity and temperature, which have profound effects on other quantitative characters[2,3]. It is, in fact, largely independent of

external conditions. This has led to the suggestion that the variability is mainly due to "intangible accidents of development"[2]; but it may be argued that this does not really solve the problem, and the statistical facts need to be brought into relation with what is known about the morphogenesis of chætæ.

The relevant facts are as follows. A pair of small islets of embryonic cells, the hypodermal histoblasts, become visible four hours after formation of the puparium; they spread and form the ventral imaginal hypodermis of each abdominal segment during the next thirty hours. Towards the end of this period, the trichogen cells appear in the hypodermis, enlarge, and each gives rise to a chæta[4]. Each chæta is innervated by a bipolar nerve cell[5,6]. Various macrochætæ have a temperature-effective period in the late larva[7], and this has been taken to indicate that the trichogen cells are already in existence then, long before they can be seen[4]; but the temperature-effective periods for microchætæ do not appear to have been studied. What conclusions can we draw from these facts?

Since most of the external surface carries chætæ in more or less regular patterns, the tendency to produce them must be a general property of imaginal hypodermis; and, in view of the rapid development of the hypodermis from small groups of embryonic cells, it seems probable that the trichogen cells are induced shortly before they become visible, and do not exist earlier. It may be suggested that local irregularities in the newly formed hypodermis cause the induction of the trichogens and that some mechanism prevents them from forming too close together. This mechanism is almost certain to be connected with the rapid growth of the trichogen cells, which would exhaust certain materials in the immediate neighbourhood of each, and thus inhibit the formation of others near by. This leaves us with the problems of what could cause local irregularities in the hypodermis, and what could be responsible for the uncorrelated variations in numbers of chætæ.

Local irregularities could be caused by many factors, including the early presence of the nerve cells which later underlie the chætæ. But nothing is known of the history of these cells, and they may well be induced at the same time as the trichogens, or by them. It seems, in any event, far-fetched to attribute the regularity of the surface patterns to the regularity of underlying nerve cells. Any disturbance of the potential uniformity of the hypodermal tissue might be sufficient to set off the production of trichogen, and the regularity of the chætæ would then be maintained by the inhibitory mechanism postulated above. But we require some additional cause for the variability in number of chæta on each segment. The factors responsible cannot easily be equated with any known environmental variables, for the reasons given earlier, and must be very local in effect.

One agency which may contribute to this variation is somatic mutation. Genetic homogeneity of somatic tissue certainly cannot be assumed; and, since the hypodermis forming each abdominal sternite contains large numbers of cells, sufficient mutations might occur to affect the probability of production of chætæ at any point, and thus to vary the density of chætæ. Another possibility is that random disturbances acting on the newly formed hypodermis might destroy its homogeneity at a number of points, and so affect the siting of the chætæ. Thus, it has recently been suggested[8] that slight random disturbances could set off a chain of reactions in a homogeneous tissue leading to the production of a variable pattern, for example, dappling.

These suggestions are largely speculative, but may serve to encourage further study of the morphogenetic basis of production of chætæ. The facts put forward certainly reinforce our previous conclusion[3] that most of the non-genetic variation in number of abdominal chætæ, under normal culture conditions, is not an 'environmental' variability of the kind we meet in dealing with most quantitative characters. Such chance—or stochastic—variability may well be a property of many pattern characters. [Oct. 28.


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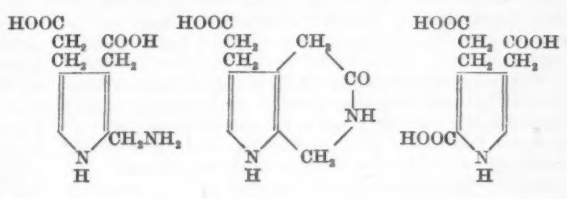
# PORPHOBILINOGEN

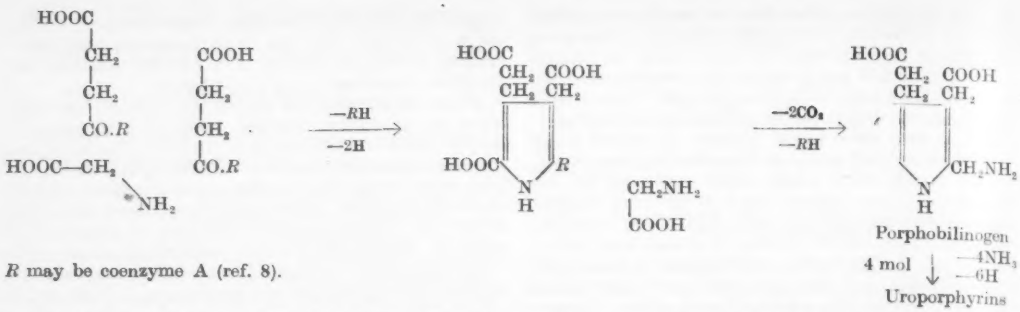
## Chemical Constitution

THE urine of patients suffering from acute porphyria contains a compound, porphobilinogen, which gives a positive Ehrlich reaction and which can be converted into a mixture of uroporphyrins on heating with acid[1]. Porphobilinogen was recently isolated in crystalline form by Westall[2], who kindly provided the material for this investigation. The reactions summarized below show that it probably has the structure (I). In an accompanying communication, Mrs. Kennard presents X-ray crystallographic evidence in support of a formula containing a single pyrrole ring.




Porphobilinogen boiled with phosphate buffer (*p*H 8·5) loses ammonia but does not do so at 40°[2]. 2 : 4-Dinitroaniline has been isolated after treatment of a porphobilinogen solution at *p*H 8·5 and room temperature with 1 : 2 : 4-fluorodinitrobenzene.

When dissolved in strong alkali such as caustic soda or aqueous triethylamine, porphobilinogen gave, on treatment with acetic anhydride or benzoyl chloride, what were assumed to be the corresponding acyl derivatives; owing to their water solubility these could not be isolated. They were recognized on paper chromatograms run in butanol – 20 per cent acetic acid and developed with Ehrlich reagent (acetyl $R_F$ 0·79, benzoyl $R_F$ 0·92). However, when a solution of porphobilinogen in aqueous pyridine was treated with acylating agents, the major product was the lactam (II), which was unchanged by solution in caustic soda and further treatment with acetic




*R* may be coenzyme A (ref. 8).

anhydride. The lactam (II) ($R_F$ 0·65. Found: C, 57·6; H, 5·9; N, 12·9. $C_{10}H_{12}O_3N_2$ requires C, 57·7; H, 5·8; N, 13·45 per cent) with diazomethane gave its methyl ester, melting point 248–250° ($R_F$ 0·83. Found: C, 59·6; H, 6·6; N, 12·6. $C_{11}H_{14}O_3N_2$ requires C, 59·4; H, 6·3; N, 12·6 per cent). Both (II) and its ester showed a brilliant blue fluorescence under a Wood's lamp, but the only strong absorption in the ultra-violet was at *c.* 210 mμ, ε 7,500, as expected of a pyrrole with no conjugated chromophore[3].

The methyl ester of (II) underwent a Hoesch reaction with acetonitrile and hydrogen chloride to give its α-acetyl derivative. The product of the reaction, which was carried out on only 8·2 mgm., was investigated spectroscopically, the intermediate ketimine hydrochloride having $\lambda_{max.}$ 331 mμ and the acetyl derivative 306 mμ (cf. 2-acetyl-4-ethyl-3 : 5-dimethylpyrrole, 308 mμ[3]). 2·7 mgm. of the pure 2 : 4-dinitrophenylhydrazone were obtained (found: N, 19·2. $C_{19}H_{20}O_7N_6$ requires N, 18·9 per cent).

The infra-red spectra of porphobilinogen, the lactam (II) and its ester, which were kindly measured by Dr. L. A. Duncanson, of Imperial Chemical Industries Butterwick Research Laboratories, are in accordance with the structures assigned to them. The alternative structures with the positions of the β-substituents in (I) reversed, leading to a seven-membered lactam, have not yet been rigidly excluded.

The porphyrin formed when porphobilinogen was heated in acid solution yielded a crystalline octamethyl ester, melting point 255°. On paper chromatography[4] the major part of the material behaved as uroporphyrin III, but at least one other isomer was present. To explain the formation of a mixture of isomeric uroporphyrins *in vitro*, it has been suggested that porphobilinogen itself is a mixture[5]. We regard this as unlikely, X-ray (see accompanying communication) and chemical evidence being in favour of homogeneity. Other examples exist of the formation of mixtures of isomeric porphyrins from single compounds[6].

Isotopic tracer studies of hæm biosynthesis[7,8] have shown that natural porphyrins are synthesized from glycine and an unsymmetrical succinic acid derivative arising from the tricarboxylic acid cycle. Determination of the positions of the labelled atoms in the hæm led to the suggestion of (III) as an intermediate, which was then in some way converted to uroporphyrin, the methene bridges of which were derived from the α-carbon atom of glycine[9]. The structure of porphobilinogen which we now put forward can be immediately fitted into the scheme at the top of the page.

We are carrying out further work on this subject, and our results will be reported in full at a later date.

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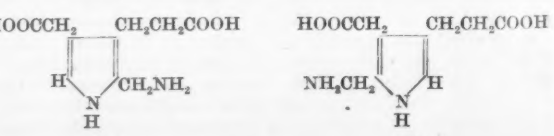
## X-Ray Crystallographic Determination of Molecular Weight

A PORPHYRIN precursor, porphobilinogen, was recently isolated by R. G. Westall in the form of the pure crystalline base[1] from the urine of patients suffering from acute porphyria. Chemical evidence by Westall[1] and by G. H. Cookson and C. Rimington (accompanying communication) suggests an empirical formula of $C_{10}H_{16}O_4N_2$ or $C_{10}H_{14}O_4N_2$ respectively. No molecular weight could, however, be assigned to porphobilinogen, and a crystallographic examination was undertaken to determine this and to differentiate between possible pyrrole or dipyrrylmethane structures, Waldenström and Vahlquist[2] having favoured the latter on the basis of diffusion experiments with porphobilinogen concentrates. In addition, it was hoped that the method would indicate whether or not two position isomers (*A* and *B*) were present. Intermediates of this type with unspecified α-substituents were postulated by Neuberger, Muir and Gray[3] in their theory of the biosynthesis of porphyrins.

Crystallographic methods were recently used to differentiate in a similar way between the various porphyrin isomers[4].



COMPARISON OF UNIT CELL DIMENSIONS

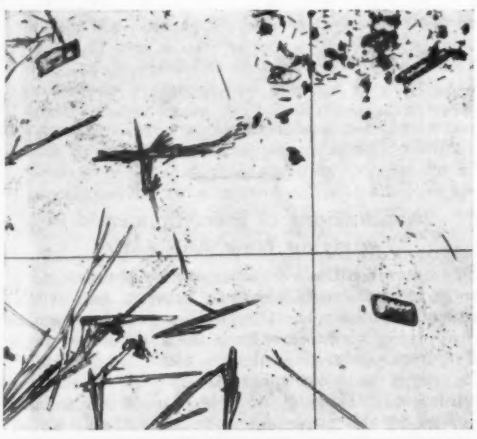
| Substance | $a$ | $b$ | $c$ | $\alpha$ | $\beta$ | $\gamma$ | No. of molecules | Space group |
|---|---|---|---|---|---|---|---|---|
| Porphobilinogen HCl $H_2O$* | 13·9 A. | 17·9 A. | 5·34 A. | 97° | 97° | 89° | 4 | $B1$ or $B\bar{1}$ |
| α-Porphobilinogen HBr $H_2O$* | 14·0 | 18·0 | 5·34 | 97° | 97° | 89° | 4 | $B1$ or $B\bar{1}$ |
| β-Porphobilinogen HBr | 15·7 | 15·4 | 5·23 | 90° | 96° | 90° | 4 | $P2_1/n$ |
| Coproporphyrin I tetramethyl ester | 11·1 | 17·4 | 5·50 | 93° | 96° 40′ | 123° | 1 | $P1$ or $P\bar{1}$ |

* Referred to a $B$ face-centred cell twice the volume of the primitive cell

*Porphobilinogen hydrochloride.* The free base was converted into the hydrochloride by treatment on a silicone-coated slide with cold 2$N$ hydrochloric acid. The fine needle-shaped crystals appeared optically homogeneous. Centrifuged in a Linderström–Lang type density column[5] the crystals formed one sharp band at a density-level of 1·405 gm./c.c. The X-ray diffraction pattern of a number of separate crystals was identical.

Porphobilinogen hydrochloride was found to be triclinic. Cell dimensions, calculated from rotation and Weissenberg photographs, were $a = 7{\cdot}5$ A., $b = 17{\cdot}9$ A., $c = 5{\cdot}34$ A.; $\alpha = 96° 17′$, $\beta = 117° 8′$, $\gamma = 87° 27′$. Mass per unit cell (O = 16) calculated from the above data is $553{\cdot}3 \pm 25$. Analytical values agree with the formula for the monohalide with one molecule of water; molecular weight calculated for two units of $(C_{10}H_{14}N_2O_4HCl,H_2O)$ is 561. Piezoelectric tests, as well as the Wilson statistical tests[6], failed to decide the presence or absence of a centre of symmetry. Accordingly the unit cell may contain one molecule of dipyrrylmethane, or two molecules of monopyroles which may or may not be position isomers.

*Porphobilinogen hydrobromide.* When converted to the hydrobromide, porphobilinogen crystallized in two forms, the α-form, isomorphous with hydrochloride, and β, a monoclinic form, prismatic in appearance (see photograph). The two forms occurred together, in variable proportions, and attempts to produce one form alone were unsuccessful. To obtain fractionation, use was made of the difference in the specific gravity of the two forms, and complete separation achieved by centrifuging the material in a density column of suitable gradient.



Porphobilinogen hydrobromide, showing the long needle-shaped crystals of the α (hydrated) form and the prismatic habit of the β (anhydrous) form. Magnification × 80

The unit cell dimensions of the α-form were found to be: $a = 7{\cdot}5$ A., $b = 18{\cdot}0$ A., $c = 5{\cdot}34$ A.; $\alpha = 96° 14′$, $\beta = 114° 8′$, $\gamma = 87° 24′$. Observed density 1·587 gm./c.c. The total molecular mass (O = 16) calculated from X-ray data is $628 \pm 25$. The molecular weight calculated for $(C_{10}H_{14}N_2O_4HBr,H_2O)_2$ suggested by the analytical data is 649·8. Again no distinction could be made between space groups $P1$ and $P\bar{1}$.

The β-form has been examined chromatographically by Cookson and Rimington and found to be homogeneous and convertible to an octa-carboxyl porphyrin. It crystallized in space group $P2_1/n$. Absent reflexions: $(h0l)$ if $(h + l)$ is odd; $0k0$ if $k$ is odd. Cell dimensions are shown in the accompanying table. Density, 1·595 gm./c.c. The mass per unit cell (O = 16) is 1,211 ± 50, which agrees within experimental error with the presence of four formula units of $(C_{10}H_{14}N_2O_4HBr)$, $M_{calc.}$ being 1,227·6. Symmetry considerations require that the unit cell contains either groups of four identical molecules in general positions or groups of two identical centrosymmetrical molecules in special positions. Since the proposed dipyrrylmethane molecule is extremely unlikely to have a centre of symmetry, crystallographic evidence would favour the monopyrrole structure for porphobilinogen, and shows that an octa-carboxyl porphyrin can be produced from a compound containing molecules of one type of isomer only.

The mean molecular weight for the free base calculated from the three types of crystals examined is 221; molecular weight calculated for $(C_{10}H_{14}N_2O_4) = 226$.

*Coproporphyrin I tetramethyl ester.* The unit cell dimensions of this substance have been determined and are included in the table. Similar measurements of a uroporphyrin could not be carried out for lack of suitable single crystals. Coproporphyrin I ester provides an interesting comparison with porphobilinogen as the unit cell contains one molecule, the equivalent of four pyrrole units only in a space group of $P1$ or $P\bar{1}$. The distribution of intensities in the X-ray diffraction pattern indicates that the molecule is not strictly centrosymmetrical and favours a space group of $P1$. The similarity between the unit cell dimensions of the porphobilinogen halides and this porphyrin ester suggests a common structure-type and lends indirect evidence for the proposed molecular structure of porphobilinogen.

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April 28.

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# LETTERS TO THE EDITORS

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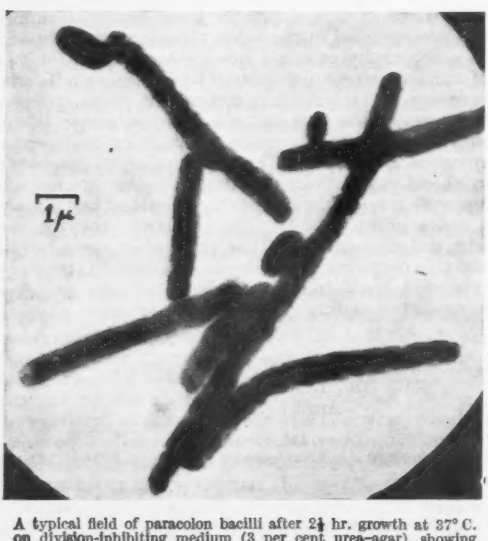
## A New Procedure for Bacterial Viability Counts and its Biophysical Applications

A BASIC problem in microbiology is that of determining the proportions of live and dead organisms in a bacterial culture. The standard procedure is to spread a known volume of diluted culture over a solid nutrient medium and then, after incubation, to count the colonies which develop. On the assumption that each colony came from one bacterium, the number of viable organisms per millilitre of original culture can be calculated (but not the percentage viability).

We have found useful a completely different method which consists simply of counting in an electron microscope the live and dead organisms in a random sample of any culture. Live and dead bacteria cannot normally be distinguished from each other. However, if the culture is incubated for a few hours under conditions which permit cell-growth but inhibit cell-division, the live organisms will grow to many times the length of their dead companions and the two kinds can readily be differentiated and counted (see photomicrograph).

A convenient agent for inhibiting division but permitting growth is urea at a concentration of 3 per cent in nutrient agar[1]. The bacteria are grown on a collodion film supported on a stainless-steel electron-microscope specimen grid in a manner similar to that described by Brieger and Cosslett[2]. The grids are placed film downwards on a Petri dish of nutrient agar containing 3 per cent urea. A drop of bacterial culture is then placed on the centre of each grid and the whole incubated at 37° C. for 3 hr. (6 hr. for irradiated bacteria, to allow for the longer lag phase). The grids are then fixed in vapours of osmium tetroxide or formalin, cleaned by floating on distilled water, and finally dried and examined. The live bacteria in the drop will have formed long filaments, whereas the dead ones remain unchanged. Provided the distribution of bacteria on the grid is suitable, a count of the live and dead cells can then be made. Test-counts on suspensions containing known proportions of live and heat-killed bacteria gave answers correct to within the expected sampling error, which is small if several hundred cells are counted. Examination in an electron microscope is probably essential for making accurate counts—especially for distinguishing very short rods from particles of medium or detritus, and for including lysed cells.




A typical field of paracolon bacilli after 2½ hr. growth at 37° C. on division-inhibiting medium (3 per cent urea–agar), showing seven live and three dead organisms

The 'urea method' is often less time-consuming and troublesome than the standard method. Its main disadvantage is that it cannot be applied to cocci, which do not respond to urea by developing into giant forms, or to cultures of organisms which always contain filamentous cells in spite of being cultured under conditions favouring short forms. But we have used it successfully with strains of *Bacterium*, a paracolon bacillus, *Chromobacterium*, and *Pseudomonas*. With suitable strains, counting by the urea method has several important advantages over the standard procedure: (*a*) it is not affected by bacterial clumping, which can entirely vitiate the standard procedure[3]; (*b*) it gives percentage viability, instead of only a total live count per unit volume; (*c*) the dead cells can be identified and examined; (*d*) only a very small sample is required.

The method has proved very useful in studying the resistance of bacteria to drying in fine droplets (as happens so often in Nature), and has also thrown new light on the effects of radiations on bacterial cells. In the latter case the counts may differ widely from those made by the standard procedure, since the urea method measures primarily radiation effects on the systems responsible for cell growth. It presumably does not detect effects on the systems responsible for cell division and heredity, which do, however, affect counts made by the standard procedure. Clearly, in most experiments on bacterial killing, fuller information can be obtained by using the two methods in parallel.

Further details of this and other work based on the urea method will be published elsewhere. One of us (R. C. V.) is indebted to the Agricultural Research Council for support during this work.

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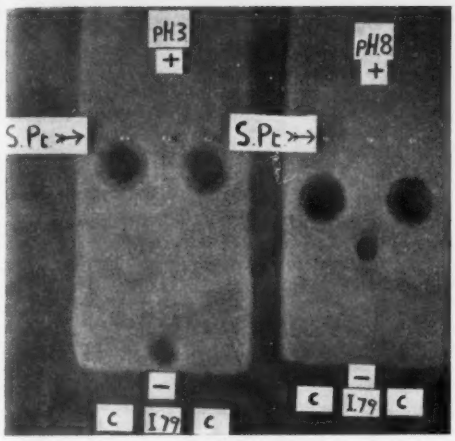
## Applications of Electrophoresis in studying New Antibiotics

THE application of paper electrophoresis to the study of new antibiotics[1] has been in use at these laboratories for some time. Our technique consists of applying spots of culture fluid, or a concentrate of it, to paper strips soaked in buffer, and subjecting the strips to electrophoresis by the technique of Kunkel and Tiselius[2]. Spots of chloromycetin are applied to the paper on each side of the spot of unknown antibiotic as a control for electro-osmosis. After migration, the position of the antibiotic is revealed by the microbiological technique as usual




Electrophoresis of antibiotic 179 relative to chloromycetin (*C*). *S.Pt.*, starting point

in paper chromatography of antibiotics[2]. Thus it is possible to determine whether unknown antibiotics in culture fluids are acidic, basic or amphoteric, and to obtain an approximate measure of their isoelectric point as a guide to subsequent purification procedures. The migration of an unknown antibiotic 179, relative to chloromycetin, to the cathode at *p*H 3 and *p*H 8, with lessened mobility at *p*H 8, indicates a basic substance with an isoelectric point greater than *p*H 8, as illustrated in the accompanying photograph.

During the course of our studies, a number of apparently anomalous results were observed which proved to be the result of one or more of the following effects: (*a*) movement of spots during the drying process; (*b*) uneven distribution of electrolytes on the paper; (*c*) adsorption of the antibiotic by the paper.

*Movement of spots during drying of the paper.* When filter papers were dried at the conclusion of electrophoresis, definite movements of spots of dye (bromphenol blue) were shown to occur due to the flow of water during evaporation. The extent and direction of the movement varied surprisingly with the conditions of drying and the relative positions of the spots on the paper. Such movements and the contraction of the whole paper on drying are factors which limit the possible agreement between measurements made by paper and classical electrophoresis.

*Uneven distribution of electrolytes.* By incorporating an indicator in the buffer used for electrophoresis, it was shown that electrolytes added along with the substance under examination may separate during electrophoresis into discrete acid and alkaline areas which disperse only slowly. Considerations were, therefore, given to the choice of buffer concentration on the paper and the concentration of electrolytes in the sample submitted for electrophoresis. This observation stresses the need for considering the entire electrolyte concentration of a solution on which paper electrophoresis is contemplated.

*Adsorption of the antibiotic by the paper.* The chromatographic development on filter paper of a number of known and unknown antibiotics with buffers demonstrated a property in common, of strong adsorption at *p*H 8 and less so at *p*H 3, while chloromycetin showed little adsorption. With a knowledge of the relative adsorptions of an unknown antibiotic and chloromycetin, it was possible to interpret electrophoretic movements of the former even when strong adsorption on the paper occurred.

*Choice of a suitable control for electrophoresis.* Chloromycetin is a suitable control because it is little adsorbed, is indicated by the same methods as the antibiotic being studied, and shows electrophoretic movement on filter paper close to that of dextran, already established by Kunkel and Tiselius[2] as a suitable control for electro-osmosis.

We wish to thank the Director of the Commonwealth Serum Laboratories for permission to publish this communication.

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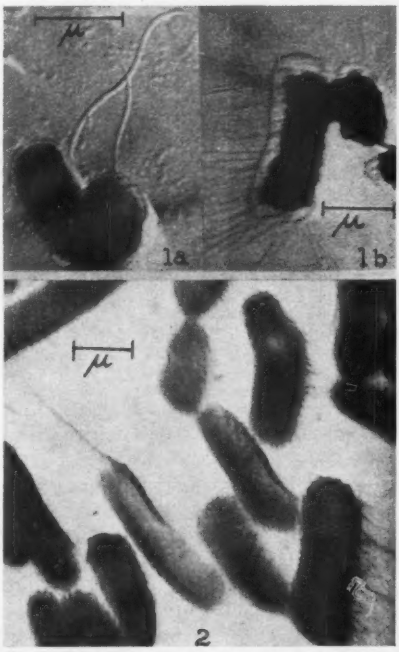
## A Variant of *Bacterium coli*

During an electron microscopic investigation of *Bacterium coli*, a variant form of this bacterium was observed with several interesting features. The accompanying electron micrographs 1(*a*) and 1(*b*) show the normal types of this bacterium usually obtained. In both cases bacteria were grown on




Electron micrographs of *B. coli* shadowed with 80 A. of chromium metal. 1(*a*) normal type fixed in 2 per cent osmic acid vapour (× 13,600); 1(*b*) normal type fixed in 5 per cent formalin (× 11,200). (2) Variant fixed in 2 per cent osmic acid vapour (× 8,800)

Morton–Engley's enriched agar medium[1] and incubated for 2½ hr. at 37° C. Bacteria represented in Fig. 1(*a*) were fixed by exposure to vapour of 2 per cent osmic acid, whereas those of Fig. 1(*b*) were fixed in 5 per cent formalin. Those fixed in formalin always showed a greater shrinkage of protoplasm from the cell wall, compared to those fixed in osmic acid vapour.

In the normal type of this bacterium, the surface of the body is smooth; two types of flagella are usually observed, the long and thick variety (Fig. 1(*a*)) which are few in number, and the narrow filamentous type (Fig. 1(*b*)), which are more profuse and peritrichous in distribution. The flagella originate from the lateral surface of the body and extend right up to the cytoplasm, as may be seen through the collapsed cell membrane in Fig. 1(*b*). Except when the cytoplasm has shrunk considerably, the body of the bacterium shows unequal transmission of electrons, possibly corresponding to the nuclear and cytoplasmic regions[2].

In the variant form (Fig. 2), the body appears hairy, and in a few cases long hairy outgrowths are twisted together and resemble a twine. The hairs seem to be of surface growth and no normal flagella are seen. The bacteria are in general more transparent to the electron beam than the normal forms. Variants of *B. coli* have been observed before by different authors[2–5]. Vaureka[3] observed a hairy variant of *B. coli* under the phase-contrast microscope, when bacteria were treated with chloramphenicol and antiserum. In this case a hairy lining membrane appeared just before the death of the cell. Eisenstark *et al.*[4] observed a mottled variety of *B. coli* after treatment with X-rays. In our case, the hairy variety was found to occur spontaneously in the normal culture, and it maintained this characteristic through several subcultures.

We wish to thank Prof. M. N. Saha for his interest in this work. We are also indebted to the Ministry of Education, Government of India, for financial assistance.

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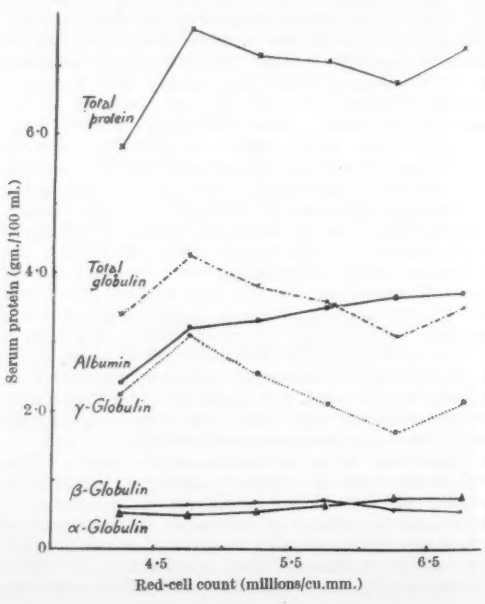
## Serum Proteins in Africans

It has frequently been observed[1] that the serum globulin-level of apparently normal Africans is higher, and the albumin-level somewhat lower, than that of Europeans. Moreover, workers in this laboratory[2] have shown that there is a relation between mean red-cell count and serum protein-levels. Those Africans with the highest red-cell counts have a higher mean albumin-level and a lower globulin-level than those with lower red-cell counts. In this work, chemical methods[3,4] for separating and estimating the serum protein fractions were used. By these methods it appeared that the variation of the β-globulin fraction accounted for the greater part of the change in total globulin in the different red-cell-count groups.

This work has now been repeated, and in the main confirmed, using a micro-electrophoresis (Antweiler) method for estimating the serum protein fractions. The proteins were measured in the ascending limb in barbitone buffer of *p*H 8·6, ionic strength 0·12. By this method serum protein-levels of normal Europeans living in Africa were found to be close to those given in the literature for normal subjects; and the means for a group of seven African medical students were similar to those of the Europeans except for the γ-globulin-level, which was more than twice the European mean.

Blood samples were taken from fifty-five surgical out-patients who reported for minor or constitutional surgical conditions which could not *prima facie* affect the serum proteins, or who required a physical examination for a health certificate. Serum protein measurements and red-cell counts were made on each sample. The figures for protein concentration were arranged in groups according to the red-cell count, and the means for each group were calculated. The results are shown in the accompanying graph. It is seen that there is a progressive increase of mean serum albumin from the lowest blood-count group (less than 4·5 million) to the highest (greater than 6·5 million). In contrast with our earlier findings, the mean α- and β-globulin-levels show little variation in the different blood-count groups, the variation of globulin occurring almost entirely in the γ-globulin fraction.

This discrepancy with the previous work is due to the fact that, in African sera, a proportion of the substances having the electrophoretic mobility of γ-globulins is not precipitated by saline ammonium sulphate, as used in the method[3] employed in our earlier work. Whereas in European sera which we have examined the figures for γ-globulin obtained by electrophoretic and chemical methods agree well, in African sera the chemical figure is always lower than the electrophoretic figure. By the method of Wolfson *et al.*, the β-globulin concentration is found



by difference, that is, the values for (albumin + α- + γ-globulin) are subtracted from the total protein; and if by this method the γ-globulin is under-estimated, falsely high figures for β-globulin must be obtained. It appears from our later experiments that the variation in the different blood-count groups occurs mainly in that part of the γ-globulin which fails to be precipitated by saline ammonium sulphate.

The significance of the raised γ-globulin concentrations of African sera is now being investigated.

I am indebted to Mr. John Kyobe for red-cell counts made in connexion with this work, and to Mr. John Croot for access to the subjects.

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## Inhibitory Effect of Malonate on the Respiration of Brain Tissue, with Special Reference to the Potassium Effect

It has long been known that, in brain cortex slices, both aerobic glycolysis and respiration are enhanced markedly when potassium chloride (0·1 *M*) is added to the suspension medium[1], this metabolic effect of potassium being peculiar to nervous tissue[2] and abolished by grinding the material[3]. In view of the manner in which the increased aerobic glycolysis and respiration respond to various metabolic poisons such as potassium cyanide, malonate and mono-iodoacetate, it seems possible that the type of linkage of these two metabolic routes differs from that under normal conditions[4].

Although Dixon[5] and Dickens and Greville[6] have put forward a hypothesis to explain the underlying mechanism of the effect of potassium in terms of permeability, its nature is still obscure[4], if somewhat clarified by the recent work of Lipsett and Crescitelli[6]. In the present communication we wish to direct attention to the effect of malonate on the increased respiration caused by the addition of potassium.

Fig. 1 shows that the respiration in presence of potassium chloride is strikingly inhibited by the addition of malonate ($10^{-3}$ *M*), being depressed nearly to the level of the normal respiration, which is itself maintained steadily even in the presence of malonate[7]. If the concentration of malonate is increased to $10^{-2}$ *M*, respiration in presence of potassium chloride is completely inhibited, even to the level of the endogenous respiration of the brain tissue without added substrate, as seen from Fig. 2 (*a*) and (*b*). Again, the respiration in the normal saline medium remains substantially resistant to malonate, whether glucose is present or absent. Thus the respiration in presence of excess potassium is acutely susceptible to malonate as contrasted with the normal respiration, which is quite resistant to the same poison.

In view of these facts, bearing in mind that malonate tends to promote the increased aerobic glycolysis due to potassium and further that the potassium effect is reversible, the possibility suggests itself that in potassium chloride – saline, either the Krebs cycle is the main pathway of brain tissue respiration, or the Krebs cycle, which is masked in some way or other under normal conditions, is opened up and brought into operation by the addition of excess potassium. Even though the mode of action of potassium on these metabolic processes is at present still a matter of conjecture, it must be significant

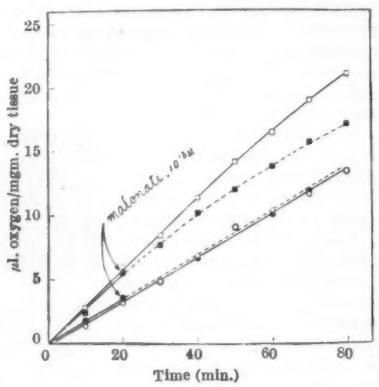


Fig. 1

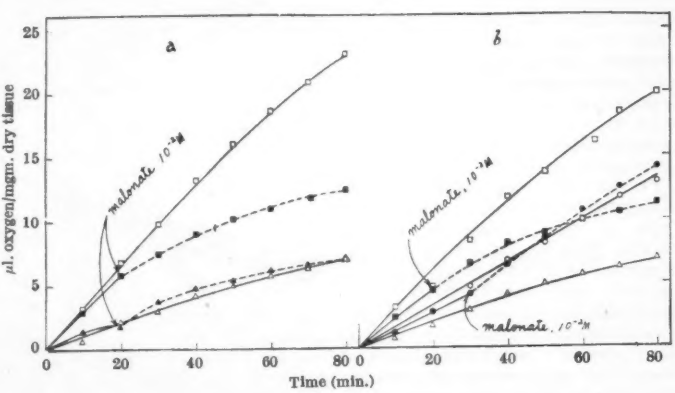


Fig. 2

Fig. 1 and Fig. 2 (*a*) and (*b*). Effects of malonate on the respiration of brain cortex slices of guinea pigs in presence and absence of excess potassium chloride; suspension medium, Krebs–Ringer phosphate solution.

□—□ control, ■—■ 'test' } glucose + 0·1 *M* potassium chloride;
○—○ control, ●—● 'test' } glucose alone; △—△ control, ▲—▲ 'test' } no glucose

Broken lines represent respiration ('test') after addition of malonate; continuous lines the respiration in the corresponding controls without malonate

that the increased respiration of brain tissue in presence of excess potassium is completely inhibited by malonate. This work is still in progress, and fuller details will be published later.

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## Nerve Fibres in the Adrenal Cortex of the Rat

It is generally accepted that the adrenal medulla receives a predominantly pre-ganglionic nerve supply, reaching it via the great and lesser splanchnic nerves and by branches from the lumbar sympathetic chain[1–3]. Such fibres traverse the cortex in compact bundles (Fig. 1), without branching or relaying in the cortex, and are easily demonstrable by silver impregnation methods, as is the medullary nerve plexus which they join.

On the subject of an intrinsic nerve supply to the adrenal cortex, opinions differ widely. Thus Stöhr[4] believed the cortex to be richly innervated, whereas earlier, Hoshi[5] had stated that it possessed no nerve supply. Hollinshead[1] found no clear-cut example of a cortical innervation following silver impregnation; he did, however, describe single fibres and small groups of fibres distributed with the cortical blood-vessels and losing themselves upon these vessel walls. He assumed that these nerve fibres were postganglionic on the grounds that they persisted after section of selected ventral nerve roots. More recently, Kiss[3], using a silver impregnation method, has claimed that the outer cell layers of the cortex are innervated by collaterals from a rich subcapsular nerve plexus. This innervation, he states, comprises both postganglionic sympathetic and sensory fibres, and joins the "grundplexus" of Boeke[6]. He claimed, moreover, to have demonstrated occasional button-shaped nerve endings in relation to the cortical cells. Protagonists of a cortical innervation have not supported their work with photographs.

In recent work, adult male albino rats were injected intravitally with a 0·5 per cent solution of methylene blue in 0·3 per cent aqueous sodium citrate[7]. Using a transfusion apparatus and a broad-bore intravenous needle, the femoral vein was cannulated and a dose of about 40 mgm. of methylene blue was usually given before death ensued after twenty minutes. The glands were fixed in 8 per cent ammonium molybdate at 0° C. overnight, then washed in ice-cold saline, rapidly dehydrated, cleared and finally embedded in paraffin. Sections ranging from 6 to 20 $\mu$ thick were mounted in balsam.

Structures very suggestive of nerve fibres and nerve endings were observed in the outer layers of the cortex (Fig. 2). They were stained a deep purple colour, in contrast to the pale blue of the connective tissue. Two varieties of these fibres were present: (*a*) a fine plexus running with the cortical arteries (Fig. 2), with a possible extension over capillary walls; (*b*) branching systems of fine and frequently beaded fibres with occasional button-shaped endings in close relation with cortical cells. In Fig. 2 this relationship can be appreciated, since some of the cell nuclei have been stained by the dye. Both types of fibre distribution appeared to be derived from a subcapsular plexus in which small darkly stained ganglion cells could be occasionally discerned. The first type of nerve distribution, that is, along vessel walls, although most frequently seen in the subcapsular region, zona glomerulosa and zona intermedia, could often be found in the zona fasciculata, but not deeper in the

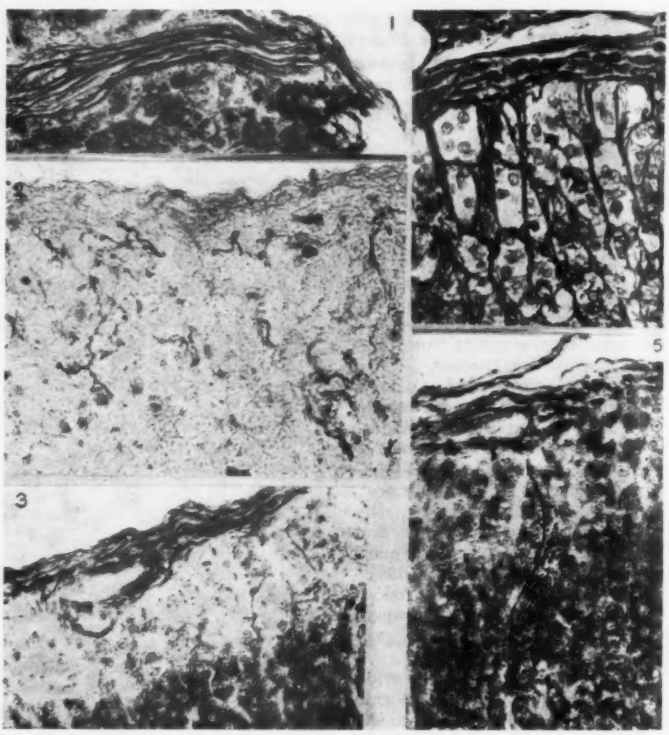


Fig. 1. A bundle of myelinated medullary nerves traversing the cortex, 12 $\mu$. Silver stained. × 320

Fig. 2. Nerve fibres and nerve endings in the outer layers of the cortex. At bottom right is a nerve plexus around an arteriole. Stained intravitally with methylene blue. 12 $\mu$. × 320

Fig. 3. Silver impregnation showing fine nerve fibres in the zona glomerulosa and also an arteriole transected deep to the capsule with a rich nerve plexus around it. 12 $\mu$. × 320

Fig. 4. Silver impregnation to show glandular reticulum. 12 $\mu$. × 320

Fig. 5. Silver impregnation showing a fine nerve fibre winding down into the zona fasciculata of the cortex. 12 $\mu$. × 320

gland. The second type of distribution, as judged by recognizable buttons in relation to cells, was apparently confined to the zonæ glomerulosa and intermedia and the outermost zona fasciculata.

In order to follow up these findings, two silver impregnation techniques were used[8,9] for demonstrating reticulum (Fig. 4) and nerve fibres (Figs. 1, 3 and 5). While no absolutely convincing nerve endings were seen by silver impregnation, yet some of the appearances were very much akin to the buttons made visible by methylene blue preparations. However, fine nerve fibres were often seen, both as a network around small arteries (Fig. 3) and singly (Fig. 5) or in groups, in relation to the cells of the zonæ glomerulosa, intermedia and outermost fasciculata. All these fibres were much finer than the obviously myelinated fibres to the medulla which transverse the cortex in bundles (Fig. 1), and also finer than the strands of reticulum (Fig. 4).

These findings suggest therefore that, in addition to a possible vasomotor innervation, the adrenal cortex may possess a nerve supply to its outer cell layers. It would also seem that intravital injections of methylene blue provide a useful means of studying these nerves. Further work on this problem is being attempted.

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## A Possible New Principle in Taxonomy, and its Evolutionary Implications

In the course of studies on the taxonomy of Coleoptera, lasting many years and dealing with groups at all levels from sub-orders down to species, it has gradually been borne upon me that taxonomic groups are not usually to be distinguished from the nearest related ones by more than one really constant character. Expressing the same concept in another form, if a taxonomic group is distinguished from related ones by the possession of character *A*, its constitution will not be quite the same as it would be if it were defined by the possession of character *B*. From superficial observation, the same principle appears to hold very generally in the animal kingdom, and quite probably among plants as well. Though this circumstance may well be familiar to many taxonomists, it does not appear to have been explicitly recognized as a general principle hitherto; if it is ultimately considered worthy of a name, I suggest 'the non-congruence principle'.

The implication of the non-congruence principle seems to be that differences of the sort used by taxonomists normally evolve one at a time. If any general statement can be made about taxonomic characters, it is probably that they exhibit more-or-less marked discontinuities but do not segregate like single gene mutants. The discontinuities are therefore presumably adaptive rather than genetical in origin, that is, they result from the relative inadaptiveness of the intermediate conditions; the evolutionary changes producing the differences were presumably relatively rapid. Genetical analysis of segregation in interspecific and intergeneric hybrids suggests that such differences involve changes in numerous genes.

To a non-specialist geneticist like myself, it seems quite plausible to assume that, if an adaptive change 'gets under way' involving a co-ordinated shift in a large number of separate hereditary factors, the genetical machinery of a species is liable to become 'tied up' in a way which would render it difficult or impossible for another change of the same type to be carried out simultaneously. If so, an explanation is provided for the apparent inability of selection to operate on more than one taxonomic character at a time, and the non-congruence principle would follow as a necessary consequence.

To take a familiar zoological instance of the possible application of the principle, we may consider some of the characters of the class Mammalia. The characteristic dentition, the secondary palate, the lower jaw suspension, the fur-clad skin, viviparity—in distinguishing Mammalia from Reptilia these characters are almost equivalent; but not quite, for the criterion of viviparity would exclude the Monotremata from the mammals, while the dentition alone would include a large number of Theromorph reptiles, and the secondary palate would include some of the later Theromorpha. According to D. M. S. Watson, there is some reason for supposing that the hairy skin first appeared with the small Ictidosauria (for example, *Oligokyphus*), that is, in succession after the dentition and secondary palate but before the truly Mammalian jaw-articulation. It may, of course, be objected that we know little or nothing of the adaptive significance of the changes involved in this instance, so that their serial occurrence might well be attributed to functional necessity, each change providing a necessary prior basis for the next. The account of the evolution of the horse given by G. G. Simpson seems to offer another example; the three major shifts—that from four toes to three in the Oligocene period, that from low to high molar teeth in the Miocene, that from three toes to one in the Pliocene—apparently occurred in regular succession though there is no evident adaptive reason why the first and second, or second and third, should not have gone on concurrently.

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## Physiological Forms of *Eucalyptus citriodora* Hooker

Since the discovery by Penfold and Morrison in 1927[1] of physiological forms in *Eucalyptus dives* Schau., many other examples of this phenomenon have been found in the Myrtaceæ and also the Rutaceæ[2]. The term 'physiological form' is applied to those plants in a naturally occurring population which cannot be separated on morphological evidence, but which are readily distinguished by marked differences in the chemical composition of their essential oils.

In 1948, the occurrence of a physiological form of *E. citriodora* was recorded[3] in which citronellal, the principal constituent of the 'type', had been almost entirely replaced by an equivalent amount of citro-

nellol and its esters. The original tree in which this unusual oil was found gave a yield of 1·4 per cent of an oil containing 10·9 per cent citronellal, 33·7 per cent citronellol and 42·4 per cent esters calculated as citronellyl acetate.

Seed from open-pollinated flowers was collected from this tree, and from this seed 243 individuals were raised. Apart from a few stunted trees, the majority showed outstanding vigour and, when cut for distillation two and a half years after planting in the field (three years from sowing), averaged 16 ft. in height.

Whereas seed from the ordinary 'type' *E. citriodora* has always given progeny with a normal aldehyde oil similar to the original parent tree, in this case great variations in oil composition as well as yield were obtained on distillation and analysis. The yields varied from less than 0·1 per cent to 1·4 per cent (fresh commercial cut), and the aldehyde contents varied from nil to 82·2 per cent. Twenty-seven trees yielded insufficient oil for analysis.

It was found possible to group the oils obtained from the progeny into four series, as follows.

(1) Aldehydes 65–85 per cent, corresponding to a normal 'type' *E. citriodora*. Seventy-seven trees, equivalent to 40·1 per cent of the oils analysed, fell into this 'aldehyde inheritance' group.

(2) Aldehydes less than 30 per cent and very soluble in 70 per cent alcohol, corresponding to the original parent tree. Forty trees, or 20·8 per cent, fell into this 'alcohol – ester inheritance' group.

(3) Aldehydes less than 30 per cent but highly insoluble in 70 per cent alcohol. A total of 9·8 per cent of the oils showed this 'hydrocarbon inheritance'.

(4) Aldehydes 30–50 per cent. This group, which is intermediate between groups (1) and (2), accounted for 29·2 per cent of the oils analysed.

Before the progeny trees were ready for cutting, a further survey of the area where the original variant had been found led to the discovery of two forms corresponding to groups (3) and (4) above, as well as more trees with the alcohol–ester type of oil[4]. All these trees were found within a radius of 50 yd. from the original tree. Therefore, all four groups of oils obtained from the progeny trees have been found in Nature.

A similar occurrence to that recorded above has previously been noted in *Leptospermum citratum*[5]. The normal aldehyde oil trees always give progeny with aldehyde oils, the hydrocarbon form always gives a hydrocarbon oil; but the alcohol–ester form gives a variable progeny including alcohol–ester oils, intermediate oils and hydrocarbon oils.

Further breeding work is being carried out with the various forms in order to determine the actual mode of inheritance of these compounds. It appears likely that in both species a similar mechanism is in operation.

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J. L. Willis

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Nov. 27.

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## Effect of Grafting on Nodulation of *Trifolium ambiguum*

The clover *Trifolium ambiguum* is a perennial species which has a somewhat restricted natural range in the Caucasus region and the neighbouring steppes, extending westwards to about the Crimea. As an introduction in the United States, it has attracted much attention as a prospective pasture plant for more favoured northern sections because of its deep-rooting habit, capacity to spread by rhizomes and considerable degrees of both drought and winter hardiness. Furthermore, as it produces nectar freely and the corolla tube is shallow, it is of particular interest with respect to honey production. However, as a legume it has an outstanding weakness in that effective nodulation of this species has never been found. Parker[1] tested on it some thirty-five strains of *Rhizobium trifolii* and, although most of them produced a certain degree of nodulation, the nodules almost without exception were very small, quite withered, brown, unhealthy and obviously ineffective. In general, these nodules occurred at the point of origin of a small root, as though rhizobial infection of this species occurred as the result of the rupture of the root tissue by an emerging branch root, as reported by Allen and Allen[2] for *Arachis hypogea*, and not through root hairs. Normally, of course, the relationship between *Rhizobium* and plant is more positive, direct and symbiotic, the bacteria reaching the cortical tissue through an infected root hair and there causing a proliferation of cells and an appreciable development of healthy nodular tissue. In the case of nodulation effective in symbiotic nitrogen fixation, the nodules are comparatively large, plump and pinkish in colour owing to the presence within them of the product leghæmoglobin.

*Trifolium ambiguum* has been grown at this Institute under conditions which resulted in good plant growth with adequate development of root hairs and on soils in which *Trifolium repens* nodulated abundantly and well; but the former has never produced any nodules.

In view of the results obtained with *Soja hispida* by Bonnier, Hely and Manil[3], it was decided to investigate the effects of grafting *Trifolium repens* on the seedlings of *Trifolium ambiguum*. Four general types of grafts were used, and all methods gave a high percentage of successes. These comprised: (1) insertion of the growing point from a seedling or older plant of *T. repens* into the split hypocotyl of *T. ambiguum*; (2) similar insertion of a longer piece of older stem of *T. repens* which had some adventitious roots for its partial support originally; these were removed later; (3) various forms of inarch grafts on the hypocotyl of *T. ambiguum* seedlings; and (4) grafting of a complete and well-nodulated root system from a seedling of *T. repens* of about the same size on to a vigorous seedling of *T. ambiguum* in the upper root–hypocotyl region, with a reduction by pruning of some of the roots of the latter.

The findings from sixty grafted plants were as follows. (1) Grafting of either plant tops or roots of *T. repens* on to *T. ambiguum* resulted in the production of relatively large and healthy nodules on *T. ambiguum*. (2) The best results were obtained when the *T. repens* was made entirely dependent on *T. ambiguum*. (3) When a true graft was produced and the scion developed adventitious roots later, its

nodules were of a large, irregular and very unusual shape for *T. repens*, and also tended to be partly green in colour although located well below the soil surface. (4) The nodules produced on *T. ambiguum* occurred on the main root and on branch roots, and either at the point of origin of a branch root or apart as though resulting from root-hair infection. (5) These nodules were comparatively large, spherical and closely resembling in form those of *T. repens*, but were white in colour and probably ineffective.

Ungrafted plants of *T. ambiguum* grown in the same pots with the above showed no evidence of nodulation in any case.

Isolations made from these nodules have been true rhizobia and have grown well on standard media; but it is not yet known if it is possible to get good nodulation directly by inoculation of plants of *T. ambiguum* grown in tubes under aseptic conditions, or whether the best results will be obtained when such material is used for inoculating plants of *T. ambiguum* again grafted with *T. repens*. However, in a late-season experiment, a small number of nodules were obtained on ungrafted *T. ambiguum* seedlings growing in pots by inoculation with material isolated from the *T. ambiguum* nodules on the grafted plants. This aspect will be investigated further.

It is considered probable that a fully effective strain of *Rhizobium* can be obtained for *T. ambiguum* by different techniques, notably by the method of successive passages through the host plant and selection of nodules obtained. However, since the development of new strains and their selection normally occur gradually in Nature, it is expected that quite a number of passages through *T. ambiguum* will be necessary before effective nodulation of this species becomes a practical possibility.

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Gembloux. Dec. 5.

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## The Respiratory Bubble of the Aquatic Beetle, *Potamodytes tuberosus*, Hinton

*Potamodytes tuberosus*, Hinton is an elmid beetle that inhabits fast-flowing water, and the present observations were made during 1952 on adult beetles occurring in a tributary of the River Densu, Gold Coast.

The bed of the river consists of large irregular rock slabs and boulders, and the fall in its level is quite rapid. During the rainy season torrential conditions prevail in the river, and the beetles were found widely distributed in the part kept under observation. During the dry season, however, the flow of water steadily decreases until the river becomes a series of rock pools and basins connected by little channels and waterfalls. It was found at this stage that although the rate of flow through the rock pools was very slow, it was comparatively fast in the connecting channels. The beetles collected in these channels, clinging to the rock surface and invariably facing the oncoming current. They were never found in slowly moving or still water, or more than an inch or two below the surface. They apparently fed on the microbiological slime that covered the submerged rock surfaces and, unless disturbed, they appeared to move but little.

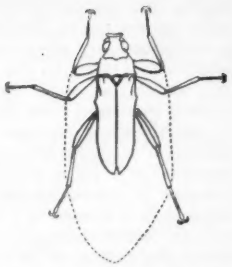

Fig. 1. Position of bubble, indicated by the dotted line, when the beetle is in a current of water

A conspicuous feature of the beetle is the respiratory bubble, clinging to its body and dragged out behind by the force of the current (Fig. 1). It would seem that certain characters of the beetle reduce the tendency of the bubble to be swept away by the current, and that under certain conditions it may extend for 1½ in. behind the beetle. It was frequently noted that the water inhabited by the beetle was broken up with bubbles of air. These coalesced continually with the respiratory bubble and thus renewed its supply of air. Observation showed, however, that the beetles also inhabited flowing water which, although saturated with air at atmospheric pressure, did not contain any visible bubbles of air. It also seemed that, under these conditions, the bubble did not shrink, as might have been expected, but acted as a permanent physical gill. This was confirmed by laboratory experiments. In slowly circulating air-saturated water, the bubble gradually disappeared and the beetle died in a few hours; in an artificial current the bubble did not disappear, and on occasion, in fact, increased considerably.

The following hypothesis is put forward as a possible explanation of the permanent nature of the respiratory

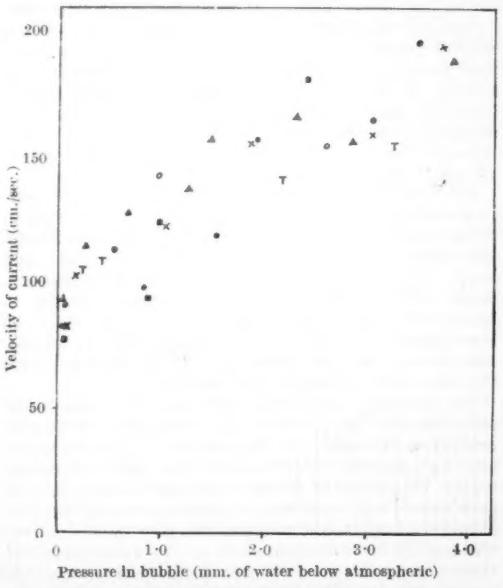


Fig. 2. Effect of the velocity of current on the pressure of the gas in the respiratory bubble. Observations were made on six separate beetles; each set of symbols refers to the results obtained from an individual beetle

bubble. The principle involved, which is most familiar in its application to the design of the aeroplane wing, is explained in elementary text-books on aerodynamics. Owing to the presence of the beetle, the velocity of the water immediately surrounding the beetle is increased relative to the velocity of the water in neighbouring regions. As a result, there is a reduction in pressure according to the Bernoulli equation $p + \frac{1}{2}v^2 = a$ constant. This reduction in pressure is communicated to the bubble. If the beetle is in a stream of water that has been saturated with air under atmospheric pressure, the water which enters the region of reduced pressure becomes temporarily super-saturated, with the result that some of its dissolved gases tend to pass into the bubble. The loss of nitrogen, postulated for the shrinking type of air bubble, does not apparently occur under these conditions.

The pressure of the air in the bubble was measured and the results are shown graphically in Fig. 2. It will be noted that above a certain critical velocity of the current, the pressure recorded in the bubble fell below atmospheric pressure. While not constituting absolute proof of the hypothesis put forward, it would seem that this result lends it a considerable support.

I thank Prof. J. E. Harris, University of Bristol, for discussions on this matter, and Mr. J. W. Balfour-Browne, British Museum (Natural History), London, for the identification of the beetle.

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Sept. 26.

## A Predator on *Creontiades pallidus*, Ramb.

The mirid *Creontiades pallidus* is widely distributed throughout the Anglo-Egyptian Sudan; it is also recorded from Egypt and the Belgian Congo, where in both places it is a pest of cotton. Wilcox[1] reports that no parasites or predators of *C. pallidus* were known to him in Egypt; while Madame Soyer[2] found a geocorid bug to be the only predator of this mirid in the Congo. Since Soyer's paper, there appear to be no other references to the insects which attack *C. pallidus*.

For a number of years *C. pallidus* has been thought to be a pest of cotton grown in the Tokar Delta; Tokar is about a hundred miles south of Port Sudan and about thirty miles inland from the Red Sea coast. The insect occurs all along the coastal cultivations, which stretch from the northern border of Eritrea to a point approximately 175 miles north of Port Sudan. In all those places where *C. pallidus* was found on the coastal stretch, the predator *Chrysopa carnea* Steph. also appeared.

On January 18, 1952, and on two subsequent occasions on Tokar cotton, *C. carnea* larvæ were seen attacking nymphs of *C. pallidus*. The nymphs, although generally active, have the habit of resting within the bracts of cotton buds, and it was in these sites that the attacked nymphs were discovered. When confined in a specimen tube, a larva of *C. carnea* will readily feed on nymphs of up to the fourth instar. Once the predator's jaws are fixed in the prey, both insects can be killed in a cyanide bottle without the larva relaxing its hold. Two specimens prepared in this way are deposited in the British Museum (Natural History), and two more are to be found in the Collection Room of the Gezira Research Farm.

When reared through the last larval instar on a diet of *C. pallidus* nymphs, the predator pupated normally and adults emerged from the pupæ. Each *C. carnea* larva ate an average of 6·1 nymphs in the last larval instar of two days; while the greatest number of nymphs consumed by such a larva was thirteen in the space of five days.

While it is unlikely that *C. carnea* in the field subsists wholly upon a diet of *Creontiades* nymphs, it is probable this predator does check to some extent the multiplication of the mirid at Tokar.

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Anglo-Egyptian Sudan.

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## Purple Pigment and Protein in the Threads of the Sea Anemone, *Adamsia rondeleti*

The sea anemone, *Adamsia rondeleti*, produces coloured protein threads, from which a purple pigment can be extracted by means of distilled water. These protein threads are produced by special glandular cells of the body, and are excreted through special pores. They are used in obtaining food (small fishes or crabs), and perhaps for self-defence.

Up to now, it has not been possible to separate the pigment from the albumin with which it is conjugated without coagulating the protein, and at the same time replacing the purple colour by yellow. The purple pigment gives an intense blue fluorescence in ultra-violet light, the principal absorption maximum being at 555 mμ with smaller peaks at 465, 450 and 435 mμ. On heating, the aqueous solution becomes yellow. The purple pigment is unlikely to be 6-6′ dibromoindigotin, which has a quite different absorption spectrum. The pigment is changed to a colourless compound at *p*H 1·92 but persists at *p*H 12·36; addition of 0·1 *N* sodium hydroxide (*p*H 12·93), however, results in a yellow colour, and a smell of trimethylamine is noticed.

Vacuum desiccation transforms the aqueous solution into a micro-crystalline substance, and causes the purple colour to disappear, changing to yellow. In moist air the colour is restored.

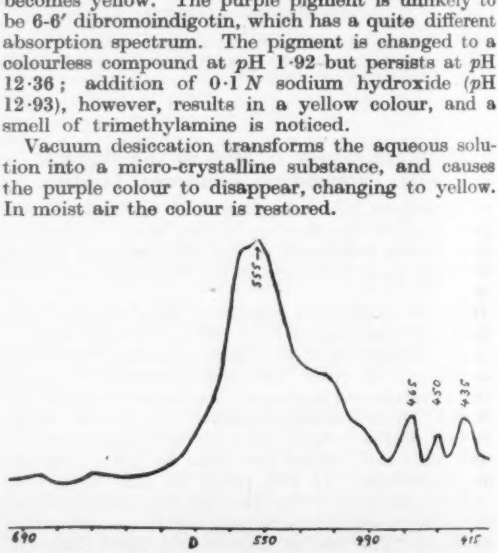


Fig. 1. Absorption spectrum of the purple pigment

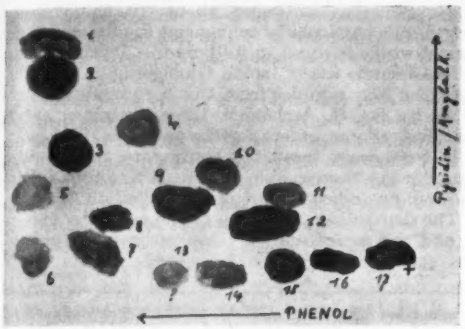


Fig. 2. Chromatogram of the purple pigment. 1, Tryptophane; 2, leucine; 3, valine; 4, tyrosine; 5, proline; 6, arginine; 7, lysine; 8, histidine; 9, alanine; 10, threonine; 11, serine; 12, glycine; 13, unknown; 14, hydroxylysine ?; 15, glutamic acid; 16, aspartic acid; 17, cysteic acid

The main pigment seems to belong to the group of the chromoproteins; but it might be a very intimate mixture with a protein. Further investigations are necessary.

Chromatography on filter paper shows the protein to contain the following amino-acids: cysteic, aspartic and glutamic acid, valine, alanine, histidine, threonine, serine, lysine, arginine, proline, tyrosine, tryptophane, hydroxylysine, and a further unidentified acid, together with tetramethylammonium-hydroxide (tetramin). The first three acids named are preponderant.

Fuller details of this work will be published in the *Bulletin of the Academy of Sciences, Athens.*

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## A Further Analysis of the Polymorphism of *Drosophila polymorpha*

THE tropical species of *Drosophila*, *D. polymorpha*, is polymorphic with regard to the pattern of pigmented abdominal bands. The polymorphism is a case of balanced polymorphism, as shown in a previous paper[1]. The types are inherited as if caused by two alleles of a single autosomic gene. The dark and the light types are the homozygotes and the intermediate type is the heterozygote. The heterozygote has an adaptive value higher than that of the homozygotes. The heterosis of the intermediate type ensures the maintenance of the two alleles in the populations. The probability that the pigmentation pattern is by itself an adaptive character is very small. Another possibility to be considered is that the two main genes responsible for the pigmentation are associated with other genes through an inversion. The differences in adaptive value could, then, be due to the genes carried in the inversion as a whole.

Using a combination of over-feeding the larvæ and a low temperature, it was possible to study the chromosomes in the salivary glands of *D. polymorpha*. A total of six inversions, three autosomic and three in the *X*-chromosome, was detected. In a total of 461 individuals from three different places, 119 were inversion heterozygotes.

No correlation was found, however, between the inversions and the pigmentation. The three pattern types may be homozygous as well as heterozygous for every one of the inversions.

The two possible explanations left for the differences in adaptive value of the three types are: (*a*) pleiotropic effects of the two genes; (*b*) genes very closely linked to the pigmentation genes. In either case, this is the first instance in the genus *Drosophila* of polymorphism not connected with chromosomal aberrations.

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Dec. 3.

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## Behaviour of Spider Crabs in the Presence of Octopuses

AT La Rocque, in Jersey, the spring tides go out about two miles leaving many large lagoons with sandy bottoms and depths of from two to four feet of water. Here we often spear flat-fish, plaice, soles, etc., sometimes getting as many as twenty in a tide; here also may be found spider crabs (*Maia squinado*), which are often taken in Jersey for food, but which are considered out of season in the autumn.

In September last, the catches of flat-fish were down to about half a dozen, owing to the number of octopuses that continually disturbed the bottom and kept the fish moving. The spider crabs had collected into large heaps, about two feet high and three feet in diameter, with their legs so entangled as to make it difficult to separate a crab from the heap. The octopuses captured some from the outside of the masses, but the greater number survived, and day after day the heaps remained. None of the fishermen to whom I have spoken of this behaviour on the part of spider crabs had ever noticed it previously.

The octopuses have now (October) moved to deeper water, and the crabs too have disappeared to their winter quarters.

H. J. BAAL
(Vice-president)

La Société Jersiaise,
The Museum, 9 Pier Road,
Jersey. Oct. 31.

## Tertiary Ocean Bottom Temperatures

DURING the past few years, a method has been developed for determining palæotemperatures by measuring the ratio of oxygen-18 to oxygen-16 in the calcium carbonate of fossil shells[1,2].

This method is based on the fact that the relative rates of deposition of the oxygen isotopes in the calcium carbonate are a function of temperature. The temperature of deposition is thus determinable from a suitably accurate measurement of the relative abundances of the oxygen isotopes in a shell. To attain the required accuracy, mass spectrometers are employed in which carbon dioxide from the shell carbonate can be alternated at intervals of two minutes with a standard carbon dioxide gas. In this way only the difference $\delta$ in oxygen-18 concentration is measured, and an accuracy of $\pm$ 0·1 parts per thousand is attained. Experiments with shells grown at known temperatures in water of known isotopic composition[1,3] have shown that:

$$t = 16{\cdot}5 - 4{\cdot}3\,\delta + 0{\cdot}14\,\delta^2,$$

where $\delta = 1{,}000 \left( \frac{R_{sample}}{R_{standard}} - 1 \right)$ and $R$ is the ratio of concentration of oxygen-18 to oxygen-16. The measure of $\delta$ is relative to our carbon dioxide standard, derived from a powdered Belemnite of the Peedee formation of North Carolina.

To obtain fully reliable results, two conditions must be fulfilled: there must be equilibrium between water and the carbonate ion deposited by the animal, and the oxygen isotopic composition of the sea water must be constant in time and uniform in space.

The first condition was verified at the beginning of this project[1]. The constancy in time of the isotopic composition of the sea water may be rather safely postulated for the time being, and could possibly be verified later by analysing the oxygen isotopic composition of fossil phosphates, sulphates or silicates, of marine deposition. As for the uniformity in space, extensive analyses of different marine waters[1,2] showed that the oxygen-18 content of sea waters having a salinity range of 32–38 per thousand varies by 2·4 per thousand. This effect is more evident in superficial waters, whereas deeper waters are more uniform. Superficial differentiation in oxygen isotopes is due to the fact that the higher vapour pressure of $H_2{}^{16}O$ with respect to $H_2{}^{18}O$ favours the evaporation of the lighter water from warm seas, and its precipitation as rain, ice, or snow, in the higher latitudes[3]. A concentration of heavier water in the lower latitudes and of lighter water in the higher ones is therefore produced. This introduces an uncertainty of $\pm$ 5·5° C. in the temperatures obtained by analysing the calcium carbonate of Recent marine animals, if no correction is applied for the variations of the concentrations of oxygen isotopes in the marine waters.

Although a similar correction cannot be applied now for isotopic variations in the oceans of the past, the uncertainty of temperature measurements would be smaller if in earlier geological times ocean waters were more thoroughly mixed, so as to produce a greater uniformity in isotopic composition and, concurrently, in salinity, temperature, etc. Such a condition is thought to have been predominant in non-glacial times. In fact, in the absence of floating ice and superficial layers of cold water with lower salinity, the warm currents from low latitudes would extend to the highest latitudes. There, they would cool to some extent, sink to the bottom, and flow back to lower latitudes as deep currents. This extended activity would produce a more uniform temperature throughout, and also increase the temperature of the bottom of the oceans[4].

To verify these considerations, two samples of benthonic Foraminifera from a deep-sea core of Tertiary age were analysed for palæotemperatures. This core was obtained by the Deep-Sea Swedish Expedition of 1947–48 in the eastern central Pacific. The geographical co-ordinates of the locality are: 15° 34′ N., and 127° 11′ W. The depth of the ocean bottom is 4,725 m., and the length of the core 348 cm. The core represents a truncated sequence of Tertiary sediments[5], of probable Oligocene age. Truncation was caused by deep current abrasion or possibly by slumping. The missing part included at least 10 m. of Pleistocene and Late Pliocene sediments, and an unknown thickness of older deposits. The Foraminiferal fauna is poor. Benthonic Foraminifera are predominantly represented by Nodosariinæ in fragments and some Rotaliidæ. These Foraminifera are rather large and thick-walled, the average diameter of the larger Nodosariinæ being about 70 Dμ (1 Dμ, a length unit particularly convenient in micropalæontological work, is equal to 0·01 mm.). Pelagic Foraminifera include scarce, small Globigerinidæ.

Of the four samples from this core made available to us by Dr. G. Arrhenius, three contained enough benthonic Foraminifera for the analyses. The benthonic tests were treated according to our standard technique[6]. Microscopic examination of thin sections showed no indication of recrystallization.

The depths below the top of the core, the value of $\delta$, and the corresponding temperatures, are given in the accompanying table.

| Depth below top of core (cm.) | $\delta$ | Temperature (° C.) |
|---|---|---|
| 2–10 | 1·51 ± 0·10 | 10·3 ± 0·5 |
| 282–290 | 1·20 ± 0·10 | 11·5 ± 0·5 |
| 339–346 | 1·74 ± 0·10 | 9·4 ± 0·5 |

Post-depositional isotopic exchange between the calcium carbonate used in the tests and sea water does not seem to have occurred. In fact, if such an exchange took place, the much lower temperature of the deep sea water during the Pleistocene and the Recent would have increased the original values of $\delta$ in our material, with consequent lowering of the calculated temperatures; although probably not to the full extent, because of the influx along the bottom of polar waters having a lighter isotopic composition. Considering our results, however, it is apparent that the original temperatures could not have been much higher.

The results seem to show, therefore, that greater mixing of the oceanic waters occurred in non-glacial times and, for these periods, this gives more general validity to calculations of palæotemperatures based on our standard formula. It also adds weight to the point repeatedly stressed by geologists that the climate of the earth was much more uniform in non-glacial times.

We are indebted to Dr. G. Arrhenius for having made available to us the material from which the results presented here were obtained.

C. Emiliani
G. Edwards

Institute for Nuclear Studies,
University of Chicago. Feb. 19.

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## Cosmic-Ray Intensity and the Temperature of the Upper Atmosphere

It is well known that the intensity of the hard component of the cosmic radiation at sea-level changes with changing atmospheric conditions. The existing correlation may be expressed by means of a linear equation:

$$(I - \bar{I})/\bar{I} = a(\bar{B} - B) + b(\bar{H} - H) + c(\bar{T} - T), \quad (1)$$

where $I$ is the intensity, $B$ is the air pressure at sea-level, $H$ is the height of the pressure level which is

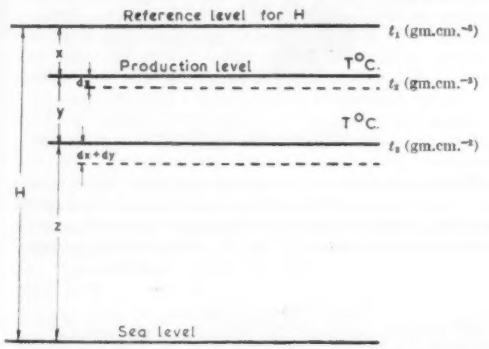
chosen to represent the average atmospheric depth of meson production, and $T$ is the temperature just below this level. A bar above a quantity denotes its mean value.

The first term of equation (1) is due to the absorption in the atmosphere. The second term is due to the decay of mesons in flight. The third term was first introduced by Duperier[1]. The observed positive correlation was interpreted as being due to competition between decay and capture of the π-mesons. The probability of decay into a μ-meson is:

$$P \approx 1 - \rho L_\pi / R_\pi, \qquad (2)$$

where $\rho$ is the density of the air, $L_\pi$ is the mean range of the π-mesons before decay and $R_\pi$ is the mean free path for nuclear absorption. It is assumed that $\rho L_\pi \ll R_\pi$, as is the case in the upper atmosphere. Equation (2) shows that this effect must give rise to a positive correlation between $I$ and $T$. However, the corresponding temperature coefficient, $c_1 = \mathrm{d}P/\mathrm{d}T$, could not account for more than one-third of the observed effect[2].

I wish to point out and discuss two other effects which may together be responsible for the apparent discrepancy. In order to simplify the discussion, we will assume that all π-mesons are produced at the same atmospheric depth of $t_2$ gm.cm.$^{-2}$ (see diagram). Because of the short mean life of the π-mesons, most μ-mesons will be produced very close to the same level. The two other pressure-levels shown in the diagram will also be used in the discussion. The variable $H$ in equation (1) denotes the height of the level at $t_1$ gm.cm.$^{-2}$, and $T$ denotes the mean temperature between this level and that at $t_3$ gm.cm.$^{-2}$.




If the levels $t_1$ and $t_2$ do not coincide, the height of the meson-producing layer will be a function of both $H$ and $T$. This will give rise to an additional temperature coefficient:

$$c_2 = \frac{1}{L_\mu}\frac{\mathrm{d}x}{\mathrm{d}T}, \qquad (4)$$

where $L_\mu$ is the mean range of the μ-mesons before decay. If $t_2 > t_1$, then $c_2 > 0$, and vice versa.

When traversing the atmosphere, the μ-mesons lose energy, and their apparent mean life will decrease. Therefore, between the levels $t_2$ and $t_3$ the mean range $L_\mu'$ before decay will be greater than the mean range $L_\mu''$ between $t_3$ and sea-level. If now $T$ increases, the distance $y$ must increase while $z$ must decrease, which gives rise to a positive temperature effect. Hence

$$c_3 = \left(\frac{1}{L_\mu''} - \frac{1}{L_\mu'}\right)\frac{\mathrm{d}y}{\mathrm{d}T} \qquad (5)$$

will give an estimate of the order of magnitude of this effect.

As Duperier[2] has measured $c$ for the two cases $t_1 = 50$ mb. and $t_1 = 100$ mb., we will also calculate $c$ for these two values of $t_1$. For the same reason we chose $t_2 = 200$ mb. (1 mb. = 1·02 gm.cm.$^{-2}$). As the meson-producing radiation is absorbed exponentially[3], with a mean range of 120 gm.cm.$^{-2}$, the average depth of production is $t_2 = 120$ gm.cm.$^{-2}$. The value of $L_\mu$ has been calculated from Duperier's height coefficient[2], $b = 3{\cdot}48$ per cent per km., which gives $L_\mu = 28{\cdot}8$ km. From the known energy loss of the μ-mesons in the atmosphere, we then get $L_\mu' = 33{\cdot}4$ km. and $L_\mu'' = 28{\cdot}2$ km. Then we use the relation $L_\pi/L_\mu \approx \tau_\pi/\tau_\mu$, where $\tau_\pi$ and $\tau_\mu$ are the real mean lives of the two kinds of mesons, to obtain $L_\pi = 0{\cdot}363$ km. For $R_\pi$ we use the geometric mean free path, which is 60 gm.cm.$^{-2}$ in air. Thus we have certainly not under-estimated $c_1$. The values of $\tau_\pi$, $\tau_\mu$ and other necessary constants were taken from Rossi's recently published book[3].

The results are, in per cent per deg. C.:

| | $t_1 = 100$ mb. | $t_2 = 50$ mb. |
|---|---|---|
| $c_1$ | 0·052 | 0·052 |
| $c_2$ | 0·019 | 0·090 |
| $c_3$ | 0·008 | 0·008 |
| $c$ | 0·079 | 0·150 |
| Duperier | 0·075 ± 0·010 | 0·143 ± 0·015 |

Duperier's results have been included for comparison. The agreement is very good. However, one must not forget that the calculations were based upon a very simplified model of the cosmic radiation. It is quite possible that the results of a more exact calculation would not agree so well with the experimental temperature coefficient; such a calculation is now in progress.

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March 5.

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[3] Rossi, B., "High-Energy Particles", 528 (Prentice-Hall, 1952).

## Scatter Fringes of Equal Thickness

IT is possible to test an optical system by means of white-light interference between two or more wave-fronts which have been scattered by equivalent obstacles out of the same collimated beam.

Consider, for example, an optical system in which a small portion of the field is strongly illuminated with white light. If a screen of moderate scattering power (say, a microscope slide which has been aluminized while in contact with a piece of lens tissue) is introduced into the entrance pupil, then the observer sees the remainder of the field stop illuminated by a diffuse diffracted halo. If a second exactly conjugate screen is placed in the exit pupil so that it appears identical with the image of the first screen except for imaging errors and for some relative displacement, white-light fringes are formed on the field stop by the two scattered beams.

Where the first screen is seen imaged without sensible error, for example, by a plane mirror, the fringes observed are of equal inclination, well-known examples being Newton's diffusion fringes and Quetelet's rings. If, on the other hand, the first screen is being imaged by an imperfect system and is adjusted to nominal coincidence with its fellow, corresponding fringes of equal optical thickness are

produced. Light scattered by the first screen suffers distortion by the system to form the error wave-front; but the second or reference wave-front is substantially free from error since its parent beam has traversed that system in concentrated fashion. The fringe pattern therefore represents the wave-front error with which the entrance pupil is being imaged on to the exit pupil, a bright achromatic fringe covering those portions of the field for which the transit time is the same as for the directly illuminated patch.

The practical possibilities of these fringes of equal thickness do not seem to have been explored. For optical testing they have one advantage in that they do not lose contrast in the presence of considerable tilt or asphericity. Of particular interest is their application to imaging systems of unit magnification such that one screen is (1) imaged by a through type or autostigmatic system on to an identical replica; (2) imaged back on to itself enantiostigmatically; or (3) repeatedly imaged on to itself in a multiple-beam arrangement.

Preliminary experiments on the first two types suggest that the fringes may be useful for testing large mirrors, camera lenses and microscope objectives, and possibly for interference microscopy. The fact that the fringes are self-compensating for path-length and, in the second case, for odd azimuthal errors suggests various engineering applications. Further investigation is taking place.

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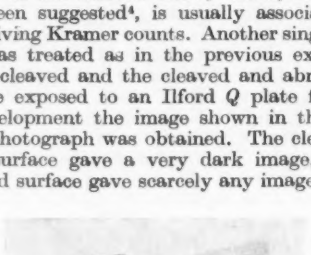
## Kramer and Russell Effects with Single Crystals of Zinc

A short while ago, Kramer[1] directed attention to the fact that abraded or worked metal surfaces emit negatively charged particles which can activate an open-ended Geiger–Müller counter operated in air. Kramer assumed the particles to be electrons, emitted owing to phase changes occurring on the freshly disturbed metal surface. Haxel, Houtermans and Seeger[2] confirmed these observations, but offered an explanation based on adsorption phenomena. Gobrecht and Barsch[3] brought forward evidence that changes of phase are not directly responsible for the phenomenon. Work at the Mechanical Engineering Research Laboratory confirmed the previous observations, but also established by measurements of ionic mobility that the particles triggering the counter are oxygen-molecule ions. It was further found that the 'active' areas behave essentially as having a lower work function than is usually ascribed to the particular metal. Abraded specimens or evaporated films gave thermionic counts at lower temperatures and photoelectric counts at longer wave-lengths than aged or unabraded surfaces of the same metal.

Experiments carried out with single crystals will illustrate this. Single crystals of zinc (kindly given to us by Dr. A. J. W. Moore) were cleaved in the (0001) plane. One of the cleaved surfaces was abraded, whereas the other was left undisturbed. Both surfaces were investigated by means of an open-ended Geiger–Müller counter operating at a pressure of 10 cm. of mercury (9 cm. mercury of air + 1 cm. mercury of ethyl alcohol). The response of the two surfaces to daylight through glass (with most of the ultra-violet wave-lengths cut off) was determined. Great care was taken to make the geometrical and illumination conditions identical in both experiments, and alternate counts were taken from the two surfaces in order to take account of the decay of the response. To eliminate stray fields from the counter, a zinc grid was interposed between counter and specimen and operated at a positive potential so that the field between the specimen and grid was 20 V./cm. Under these conditions, the cleaved surface gave 40 counts/min., whereas the cleaved and abraded surface gave 275 counts/min.

The cut-off wave-length for the photoelectric response of zinc lies normally well in the ultra-violet at about 3000 A. The fact that the cut-off wave-length had been shifted into the visible spectrum to about 5000 A. indicates that the abrasion process produces, on the surface, areas of low work function, possibly by the intermingling of oxide and metal phases.

The behaviour of the surfaces was further checked by means of the Russell effect, which, as has previously been suggested[4], is usually associated with surfaces giving Kramer counts. Another single crystal of zinc was treated as in the previous experiment. Both the cleaved and the cleaved and abraded surfaces were exposed to an Ilford *Q* plate for 20 hr. After development the image shown in the accompanying photograph was obtained. The cleaved and abraded surface gave a very dark image, whereas the cleaved surface gave scarcely any image.



(*a*) Cleaved (*b*) Cleaved and abraded

These and other experiments of similar nature lead us to believe that the abrasion of metals causes the formation of sites of low work function, and that these sites are responsible for the so-called Kramer effect.

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Dec. 10.

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## The New Classical Electrodynamics

Except for a gauge-fixing condition, Dirac's recent theory[1–3] corresponds to the natural form of Maxwell–Lorentz electrodynamics for very fine-grained streams of charged corpuscles all with the same constant mass $\mu$ and charge $\varepsilon$; the velocity field in the stream is supposed to be continuous and differentiable. The ratio $\mu'/\varepsilon$ is written $k$; here $\mu'$ is the measure of $\mu$ in energy units: $\mu' \equiv \mu c^2$. (We call this first special form of the theory the *superconductive theory*, since

its equations will be seen to be entirely equivalent to those of the relativistic form of the Maxwell–London theory when only supercurrents are present. As not all electrodynamics is superconductive, this theory is insufficiently general.) It is evident intuitively that in the uniform stream theory[3], where $\mu$ and $\varepsilon$ are everywhere constant, a non-trivial electrostatics is impossible; for example, it is not possible to describe as a static situation a charged dielectric, or any system with a space-charge which appears at rest macroscopically. For this and other reasons, connected with the existence of more than one kind of elementary particle, one is led to generalize the prequantum theory by allowing the mass $\mu$ and charge $\varepsilon$ to be variable in space-time. Such a theory may be called the general stream theory, and will be considered elsewhere. Here we confine ourselves to discussing some characteristic physical consequences of (*a*) the equations of motion, and (*b*) the gauge condition of the uniform stream theory. These follow from the assumption of:

(*a*) Differentiability of the 4-velocity field $v^\alpha = dy^\alpha/ds$ under the Lorentz law of motion, that is,

$$A_{\alpha\beta}v^\beta = -k\,dv_\alpha/ds = -kv_{\alpha,\beta}v^\beta. \qquad (L)$$

(*b*) The requirement that $A_\alpha - kv_\alpha$ be orthogonal to $v_\alpha$, that is,

$$A_\alpha v^\alpha = k. \qquad (D)$$

Here $s$ is the proper time (in light-velocity units) along the world-line $y^\alpha$ of any corpuscle, $A_\alpha$ is the electrodynamic 4-vector potential, and $A_{\alpha\beta} \equiv A_{\beta,\alpha} - A_{\alpha,\beta}$ is the space–time curl of $A_\alpha$; the comma followed by subscript $\alpha$ indicates differentiation with respect to the space–time co-ordinate along the $\alpha$-direction.

(*a*) The expression of $dv_\alpha/ds$ as $v_{\alpha,\beta}v^\beta$ assumes that corpuscle velocities at neighbouring points in space–time have neighbouring values, and that first derivatives with respect to space and time exist (except possibly for special boundaries and points). It is interesting to note that, without some assumption of this type, grave difficulties are experienced already in the older theory when one tries to obtain the relations of macroscopic phenomenological electrodynamics by averaging over the classical electron theory in a relativistically invariant way[4].

It is convenient to introduce several abbreviations. With the *kinetic field* $V_\alpha \equiv kv_\alpha$, and the potential field $A_\alpha$, we may define the *stream field*:

$$S_\alpha \equiv A_\alpha - V_\alpha. \qquad (1)$$

By adding to $(L)$ the expression $kv_{\beta,\alpha}v^\beta = 0$, which follows from $v_\beta v^\beta = 1$, we find that $S_{\alpha\beta}$, the space–time curl of $S_\alpha$, satisfies

$$S_{\alpha\beta}V^\beta = 0, \qquad (L')$$

while $(D)$ may be written: $S_\beta V^\beta = 0. \qquad (D')$

(*b*) The physically observable electromagnetic field $A_{\alpha\beta}$ is invariant under the addition to $A_\alpha$ of an arbitrary gradient $G_{,\alpha}$ and allows the freedom to impose a gauge condition. In the present theory, the chosen condition $(D)$ relates the $A_\alpha$ to the $v^\alpha$ and hence to the observable 4-current density of classical electrodynamics. It seems most natural to interpret this current density $J^\alpha$ as the manifestation of concentration and velocity in the stream of corpuscles. Thus we may write:

$$J^\alpha = N\,\varepsilon\,v^\alpha \equiv \frac{\lambda}{c^2}V^\alpha \quad \lambda \equiv c^2N\varepsilon/k \equiv N\varepsilon^2/\mu, \qquad (2)$$

where $N$, the *corpuscle concentration*, represents at each point the number of corpuscles contained in a unit co-moving volume (that is, moving along with the local stream). $N$ (or $\lambda$) is a scalar density.

Though Dirac[1] considers that only the ratio $e/m$ ($\varepsilon/\mu$) should enter into a prequantum theory of electrodynamics, it seems rather more likely, as Born[5] has remarked, that "the classical radius of the electron" $e^2/mc^2$ should also appear; this quantity occurs in theories of phenomena which are generally regarded as classical, for example, in the (J. J. Thomson) scattering of long electromagnetic waves by loosely bound electrons. We see that, with our interpretation, the field variable $\lambda = Nc^2$ $(\varepsilon^2/\mu c^2)$ does indeed introduce the characteristic length $\varepsilon^2/\mu c^2$ in a natural way. In fact, this length signifies the ratio of the current value associated with a moving corpuscle to its kinetic field value. In the superconductive theory, $V^\alpha = A^\alpha$, and $\lambda$ corresponds to $1/\Lambda$, where $\Lambda$ is the London parameter[6]. For an ordinary macroscopic superconductor, $\lambda \cong 10^{21}$ sec.$^{-2}$, and, setting $\varepsilon^2/\mu c^2 \cong 3 \times 10^{-13}$ cm., we find

$$N \cong 0{\cdot}4 \times 10^{23} \text{ cm.}^{-3},$$

or the number of 'superconducting electrons' is of the same order of magnitude as the number of atoms in a volume element.

We turn now to the kinetic consequences of the stream theory. These may be described in the following geometrical way. Any bivector at a point in the 4-dimensional realm is representable either by a single plane patch of area or, at most, by two mutually perpendicular plane areal patches. $(L')$ means that the bivector $S_{\alpha\beta}$ is totally perpendicular to the time-like 4-vector $V^\beta$ and is therefore uniplanar and space-like. Now with the gauge condition $(D')$, $S_\beta$ is also made perpendicular to $V^\beta$. $S_\alpha$ then lies in the plane of its own curl, that is,

$$S_{\alpha\beta}S_\gamma + S_{\beta\gamma}S_\alpha + S_{\gamma\alpha}S_\beta = 0,$$

and this is the necessary and sufficient condition that, with an integrating factor, $S_\alpha$ becomes proportional to an irrotational vector:

$$S_\alpha = \xi\eta_{,\alpha}. \qquad (D'')$$

This is the form which Dirac uses as the basis of his variational development[3]. It is evident that the surface $\Sigma$ determined by ($\xi$ = constant, $\eta$ = constant), at any point, is the integral manifold of $(L)$ and of

$$S_\alpha dy^\alpha = \xi d\eta = 0 \qquad (D'')$$

taken together. In other words, all world-lines or path curves satisfying $(L)$ and $(D)$ passing through the given point lie on what formally appears to be a two-dimensional surface[3] $\Sigma$. There is an apparent difficulty here from a physical point of view in that this seems to restrict unduly the possible motions of corpuscles. This difficulty is removed when we remember that $\Sigma$ is definable by its property of being totally perpendicular to the space-like plane of $S_{\alpha\beta}$ at the given point. But $S_{\alpha\beta}$ at the given point does not define a unique plane in space-time, since it depends also on the components of the *vorticity* $V_{\alpha\beta}$, themselves determined by the velocity and its derivatives. In fact, in the general uniform stream theory, the variety of possible world-lines through a point is the same as that of the possible trajectories in the traditional Lorentz particle theory. The actual restriction brought in by the condition of continuity and differentiability of $V^\alpha$ appears in the initial conditions, that is, neighbouring corpuscles must be assigned neighbouring velocities, so that bundles of

corpuscles may diverge or converge only in a gradual manner.

The case is otherwise in superconductive electrodynamics. The possible velocity distributions (and magnetic fields) associated with a given electric field are much more restricted. Here an eigen-function problem presents itself which will be dealt with elsewhere.

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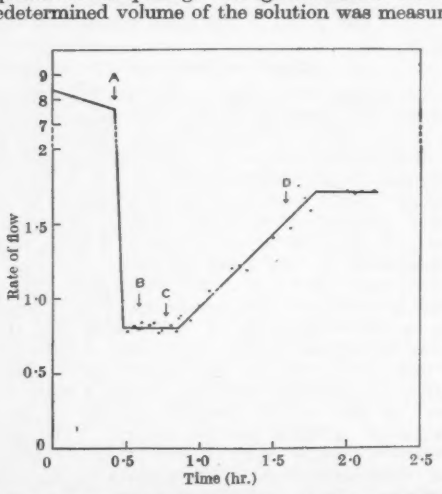
## Formation of Silicotic Tissue

Electron micrographs of normal connective tissue reveal a very fine protein network superimposed on a much coarser network[1]. The interstices are filled with protofibrils and mucopolysaccharidic acids of high molecular weight. Fibrous connective tissue is produced when lung tissue is degenerated by silica particles, the silicic acid formed by the dissolution of the silica probably being involved, and the possible analogy between the role of silicic acid and that of the mucopolysaccharides is evident.

Day[2,3] has shown that the resistance of thin sheets of tissue to the passage of saline is markedly decreased when mucopolysaccharides are removed by hyalase hydrolysis, but that subsequent treatment with chondroitin sulphuric acid again reduces the tissue permeability. Using Day's technique, we find that dilute silicic acid solutions behave in a similar manner to chondroitin sulphuric acid.

The lower orifice of a vertical tube was covered with a membrane of loose connective tissue taken from a rat. Filling the tube with saline, the time required for the passage through the membrane of a predetermined volume of the solution was measured.




*A*, Hyaluronidase added; *B*, saline added; *C*, silicic acid added; *D*, saline added

The permeability of the membrane was low. The addition of hyaluronidase to the saline caused a considerable increase in flow; but subsequent addition of a dilute silicic acid sol restored the original low rate of flow or even rendered the membrane less permeable than it was originally. A typical result is shown in the accompanying graph.

It is possible that when pathological changes are initiated by the inhalation of silica, silicic acid functions as an interfibrillary substance analogous to the mucopolysaccharides. The silica particle may thus take the role of the cell producing the macromolecules. In normal fibrous tissue, the mucopolysaccharides are being constantly destroyed by the mucopolysaccharases present in the tissue but are replaced by fresh mucopolysaccharides synthesized by fibroblasts[4,5]. Since there is no enzyme capable of hydrolysing the polysilicic acids formed, the polymers can be removed only by the slow process of physical solution, which is retarded as the silicic acid accumulates. Aluminium and beryllia, both producing macromolecules analogous to the polysilicic acids, can cause similar pathological changes.

We are indebted to the British Steel Founders' Association for financial assistance and to Benger Laboratories, Ltd., for gifts of hyaluronidase.

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S. G. Osborne

University, Reading.
March 4.

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## The Department of Scientific and Industrial Research and Aslib

The leading article in *Nature* of April 25 points out that the report for 1951–52 of the Department of Scientific and Industrial Research does not include a justification for the Department's grant to Aslib, and suggests the possibility of overlapping between Aslib and the Intelligence Division of the Department. It is right to say at once that this possibility is constantly borne in mind by the Council of Aslib, which has the advantage of close and continual contact with the Intelligence Division. Part of Aslib's activity is as a clearing-house between its own members, who include those concerned with information and library techniques in scientific and industrial and also in other fields; part consists in organizing the exchange of information on methods of documentation and publishing the results of investigations into them; part again in the promotion of training in these techniques. These things, it is believed, are outside the present scope of the Intelligence Division. In other activities—some of them carried out under contract with the Department of Scientific and Industrial Research—there is danger of overlapping; but it has been kept in mind, and it is hoped with some confidence that it has been avoided.

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(Chairman of Council)
Leslie Wilson
(Director)

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# FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

## Monday, May 18

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Mr. Braithwaite: "Principles of Choice between Alternative Hypotheses".

## Monday, May 18—Wednesday, May 20

NATIONAL TRADES TECHNICAL SOCIETIES, SHEFFIELD SECTION (at Cutler's Hall, Sheffield).—Exhibition of Laboratory Equipment.

## Tuesday, May 19

SOCIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (in the Chemistry Lecture Theatre, Royal College of Science, Imperial Institute Road, London, S.W.7), at 2.15 p.m.—Annual General Meeting; at 2.30 p.m.—Dr. H. Greene: "Tropical Soils".

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENTS SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Prof. J. Z. Young, F.R.S.: "Measurement with the Flying-Spot Microscope".

ROYAL STATISTICAL SOCIETY, STUDY SECTION (at the E.L.M.A. Lighting Service Bureau, 2 Savoy Hill, London, W.C.2), at 6 p.m.—Mr. L. Moss: "Sample Surveys and their Use for Administrative Purposes".

## Tuesday, May 19—Friday, May 22

INSTITUTION OF GAS ENGINEERS (at Church House, Westminster, London, S.W.1).—90th Annual General Meeting.

## Wednesday, May 20

PHYSICAL SOCIETY, COLOUR GROUP (at the E.L.M.A. Lighting Service Bureau, 2 Savoy Hill, London, W.C.2), at 3.30 p.m.—Scientific Papers.

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Scientific Papers.

ROYAL SOCIETY OF MEDICINE, SECTION OF COMPARATIVE MEDICINE (at 1 Wimpole Street, London, W.1), at 5 p.m.—Discussion on "Organic Manures and Fertilizers and the Production and Composition of Food for Man and Animals".

INSTITUTION OF ELECTRICAL ENGINEERS, SUPPLY SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Dr. E. C. Bullard, F.R.S.: "The Utilization of Solar Energy".

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Scientific Papers.

## Wednesday, May 20—Friday, May 22

EUROPEAN ASSOCIATION OF EXPLORATION GEOPHYSICISTS (at the Maison des Centraux, 8 Rue Jean Goujon, Paris).—Fourth Meeting.

## Thursday, May 21

SOCIETY FOR ENDOCRINOLOGY (at the Medical Society of London, Chandos Street, London, W.1), at 9.30 a.m.—Symposium on "The Determination of Adrenal Cortical Steroids and their Metabolites".

PHYSICAL SOCIETY, ACOUSTICS GROUP (joint meeting with the ROYAL AERONAUTICAL SOCIETY, at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1), at 10 a.m.—Symposium on "Aeronautical Acoustics—in particular Jet Noise".

ROSS INSTITUTE OF TROPICAL HYGIENE, INDUSTRIAL ADVISORY COMMITTEE (at the Rubber Growers' Association, 19 Fenchurch Street, London, E.C.3), at 2.15 p.m.—Discussions on "Tropical Health Problems and their Connection with Industrial Relations" (Speakers: Mr. C. R. Harrison and Prof. G. Macdonald).

CLASS OF HISTORY OF MEDICINE (in the Physiology Class Room, The University, Edinburgh), at 5 p.m.—Dr. Douglas Guthrie: "Trends and Fashions in Medicine". (Further Lectures on May 25, 28, June 1, 4 and 8.)

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. C. Lanczos: "Convergent Differentiation of the Fourier Series".

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Mr. J. W. Y. Higgs: "The Scope of Rural Collections".

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Dr. J. C. Broom: "Leptospirosis in Tropical Countries".

## Friday, May 22

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Sir Lawrence Bragg, F.R.S.: "The Discovery of X-Ray Diffraction by Crystals".

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# APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT EXPERIMENTAL OFFICER (with sound theoretical and practical knowledge of electronic and controlling instruments) IN THE PHYSICS DEPARTMENT—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting 53/9 (May 23).

CHEMISTS (Scientific Officer grade, Ref. F.185/53A, and Experimental Officer grade, Ref. F.186/53A) at Ministry of Supply Research and Development Establishments at Waltham Abbey, Sevenoaks, Farnborough, Salisbury, Westcott and Aldermaston, for work in physical chemistry, modern analytical techniques, explosives, radio chemistry, and bacterial chemistry—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No. (May 23).

LECTURER IN AIRCRAFT STRUCTURES, an ASSISTANT "B" IN ELECTRICAL ENGINEERING, an ASSISTANT "A" IN ENGINEERING DRAWING, a DEMONSTRATOR IN ELECTRICAL ENGINEERING AND PHYSICS, and a DEMONSTRATOR IN MECHANICAL ENGINEERING—The Principal, Royal Aircraft Establishment Technical College, Farnborough, Hants (May 23).

LECTURER IN METALLURGY (with a degree in metallurgy or A.I.M., together with teaching or industrial experience) IN THE CHEMISTRY DEPARTMENT—The Principal, Derby Technical College, Normanton Road, Derby (May 23).

PHYSIOLOGIST (with good honours degree in physiology, or an equivalent qualification, and research experience preferably involving the perfusion of isolated organs) for research on the physiology of lactation—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting 53/3 (May 23).

SCIENTIFIC OFFICER to assist with survey and research on soil fauna in the field and laboratory, at the Research Institute, Grange-over-Sands, Lancs—The Establishment Officer (Sc.), The Nature Conservancy, 91 Victoria Street, London, S.W.1 (May 23).

SENIOR LECTURER IN PHYSICS—The Registrar, College of Technology, Birmingham 1 (May 23).

PRINCIPAL SCIENTIFIC OFFICER at the R.A.F. Institute of Aviation Medicine, South Farnborough, to take charge of a small scientific unit concerned with effects of acceleration on man and animals, and to be responsible for detailed planning, from a fundamental aspect, of long-term programme of a physiological nature dealing largely with changes in the circulation—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.420/53 (May 28).

ASSISTANT LECTURER (Grade B) IN BOTANY—The Clerk to the Governors, Chelsea Polytechnic, Manresa Road, London, S.W.3 (May 29).

MATHEMATICIANS (Scientific Officer or Experimental Officer grades) in Ministry of Supply Research and Development Establishments at Sevenoaks, Farnborough, Amesbury and Malvern, for work in aerodynamics, aircraft structures, ballistics, radio or radar, high speed electronic calculating machines—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting A.117/53A (May 29).

EDUCATIONAL PSYCHOLOGIST—The Secretary for Education, County Buildings, Shrewsbury (May 30).

LECTURER IN CIVIL ENGINEERING (preferably with experience in structures or soil mechanics)—The Registrar, The University, Sheffield (May 30).

LECTURER IN PHYSIOLOGY—The Registrar, King's College, Strand, London, W.C.2 (May 30).

MECHANICAL AND AERONAUTICAL ENGINEERS in the Ministry of Supply Research and Development Establishments at Farnborough, Sevenoaks, Chertsey and Amesbury, for research work on (Ref. C.240/53A) aircraft and associated equipment; (Ref. C.245/53A) gas turbine engines and design work on (Ref. C.246/53A) armaments; (Ref. C.247/53A) wheeled and tracked vehicles—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No. (May 30).

SCIENTIFIC OFFICER (with a first- or second-class honours degree or equivalent in metallurgy) at a Ministry of Supply establishment in South-East London—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.159/53A (May 30).

ESSO STUDENTSHIP IN CHEMICAL ENGINEERING—The Registrar, Imperial College of Science and Technology, South Kensington, London, S.W.7 (June 1).

LECTURER IN GEOLOGY AND MINERALOGY—The Secretary, The University, Aberdeen (June 1).

GUINNESS RESEARCH FELLOWSHIP IN MICROBIOLOGICAL CHEMISTRY—The Whitley Professor, Department of Biochemistry, The University, South Parks Road, Oxford (June 6).

HEAD OF THE CIVIL AND MECHANICAL ENGINEERING DEPARTMENT—The Clerk to the Governors, Woolwich Polytechnic, Woolwich, London, S.E.18 (June 6).

LECTURER IN AGRICULTURAL BOTANY at the University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (June 6).

LECTURER OR ASSISTANT LECTURER IN PHILOSOPHY, and a SENIOR LECTURER OR LECTURER IN CHEMISTRY, at the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (June 6).

SCIENTIFIC OFFICERS (2) AT THE FOREST PRODUCTS RESEARCH LABORATORY, Princes Risborough, for research on wood bending and seasoning—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting C.99/53 (June 6).

CHEMIST (with good honours degree, or equivalent) for analytical investigational work in the Coal Survey Laboratory, Chester—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT./630 (June 8).

ELECTRONIC APPRENTICESHIPS at the Telecommunications Research Establishment and the Radar Research and Development Establishment, Malvern—The Ministry of Supply, D.T.O. (Industrial), 66-72, Gower Street, London, W.C.1 (June 8).

PRINCIPAL SCIENTIFIC OFFICER IN THE INTELLIGENCE DIVISION, Department of Scientific and Industrial Research, London—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.4204/53 (June 10).

LECTURER IN CHEMISTRY (preferably with special knowledge of agricultural chemistry)—The Principal, Seale-Hayne Agricultural College, Newton Abbot, Devon (June 13).

ESSO STUDENTSHIP IN CHEMICAL ENGINEERING—The Registrar, The University, Birmingham (June 15).

CIVIL ENGINEERS in Government Defence Departments—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.64–65/53 (June 30).

DAVID BROWN SCHOLARSHIP IN AGRICULTURAL ENGINEERING—The Registrar, King's College, Newcastle-upon-Tyne (July 15).

MYCOLOGISTS (3) (with good honours degree in botany, preferably with systematic mycology as a special subject, and some experience in identifying micro-fungi) at the Commonwealth Mycological Institute —The Secretary, Commonwealth Agricultural Bureaux, Farnham Royal, Bucks (July 15).

ASSISTANT LECTURER (primarily interested in microbiological chemistry or cell biochemistry) IN THE DEPARTMENT OF MICROBIOLOGY —The Registrar, The University, Reading (July 18).

ASSISTANT (graduate in metallurgy, physics, or chemistry) IN THE INFORMATION DEPARTMENT—The Secretary, British Non-Ferrous Metals Research Association, Euston Street, London, N.W.1.

ASSISTANT ENGINEER IN THE HYDROLOGICAL SURVEY DEPARTMENT, Uganda—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.139/9/01.

ASSISTANT ENGINEERS IN THE PUBLIC WORKS DEPARTMENT, Tanganyika—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.112/8/03.

ASSISTANT LECTURER (Grade B) IN BIOLOGICAL SUBJECTS in the Department of Chemistry and Applied Chemistry—The Principal, Royal Technical College, Salford, 5.

ASSISTANT METEOROLOGIST (with at least three years experience in forecasting for aviation) to the Gold Coast Government—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M3B/33547/NF.

BIOCHEMIST (with mature and varied experience in isolation of pure substances from biological materials) to develop and apply biological methods to synthesis of compounds labelled with Carbon 14 and other radioactive isotopes (Ref. F.180/53A); and CHEMISTS (with good all-round laboratory experience in inorganic, organic or analytical chemistry) for duties concerned with synthesis of compounds labelled with radioactive isotopes by chemical and biological methods, extraction of radioactive isotopes from irradiated materials at high levels of activity, production of radioactive appliances for medical and industrial use, associated analytical problems (Ref. F.182/53A); at the Ministry of Supply Radiochemical Centre, Amersham—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No.

BIOCHEMIST (senior grade) at the County Hospital—The Secretary, York "A" and Tadcaster Hospital Management Committee, Bootham Park, York.

CHEMIST or PHYSICIST (with good honours degree) for interesting work on problems associated with the hardening of Portland cement—The Controller, Cement and Concrete Association Research Station, Wexham Springs, Stoke Poges, Bucks.

DESIGN ENGINEERS in the Ministry of Supply at Harwell, to assist on design problems of control and instrumentation for new types of reactors—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.186/53A.

ENGINEER (Mechanical) in the Ministry of Supply at Harwell to work on mechanical design and specification of new types of reactors —The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting C.252/53A.

ENGINEERS (electrical) to assist design, planning, construction, of electrical plant and services for large new project, at Harwell—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.187/53A.

ENTOMOLOGIST (with at least second-class honours degree in entomology) in the British Solomon Islands Protectorate—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.87/45/01.

EXECUTIVE ENGINEER IN THE PUBLIC WORKS DEPARTMENT, Fiji—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.112/49/02.

INDUSTRIAL CHEMIST at Harwell to assist in problems associated with treatment of radioactive material, water supplies, and general chemical service—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.170/53A.

LECTURER IN PHYSICS, and an ASSISTANT LECTURER IN ZOOLOGY (Grade B or Grade A), at Brighton Technical College—The Director of Education, 54 Old Steine, Brighton 1.

LECTURER IN PHYSIOLOGY AND PHARMACOLOGY—The Registrar, The University, Nottingham.

LECTURER in PURE MATHEMATICS—The Head of Mathematics Department, Imperial College of Science and Technology, South Kensington, London, S.W.7.

METALLURGIST (graduate or A.I.M.) to undertake research on improved tin alloys—The Director, Tin Research Institute, Fraser Road, Perivale, Greenford.

PHYSICIST (of graduate or equivalent standing) for work involving the application of physical methods to dust problems and to metallurgical research, and a METALLURGIST (of graduate or equivalent standing) in connexion with a programme of work relating to the establishment of basic data on the physical and mechanical properties of steel in cast form—The Director, British Steel Castings Research Association, Broomgrove Lodge, Sheffield 10.

SENIOR LECTURER IN PHYSICS—The Secretary, Royal Technical College, Glasgow.

SENIOR MECHANICAL AND ELECTRICAL ENGINEER in the Public Works Department, Sudan—The Sudan Agent in London, Sudan House, Cleveland Row, London, S.W.1, quoting 'M/E Engineer 1813'.

SENIOR SCIENTIFIC OFFICER (Ref. C.237/53A) to be responsible to Head of Fundamental Studies Group for leading team engaged on fundamental engineering design studies for new types of nuclear reactors, and SCIENTIFIC OFFICERS (Ref. C.238/53A) to assist in these studies, at the Atomic Energy Research Establishment, Harwell—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No.

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# REPORTS and other PUBLICATIONS

*(not included in the monthly Books Supplement)*

## Great Britain and Ireland

Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences. No. 644, Vol. 237: A Study of the Branched Cells of the Mammalian Epidermis with Special Reference to the Fate of their Division Products. By R. E. Billingham and P. B. Medawar. Pp. 151–171. (London: Cambridge University Press, 1953.) 9*s*. [123

Scientific Proceedings of the Royal Dublin Society. Vol. 26 (N.S.), No. 7: Effects of some Single Viruses and of Combinations of the same Viruses on Three Potato Varieties. By Robert McKay and James B. Loughnane. Pp. 133–143+plates 10–11. (Dublin: Royal Dublin Society, 1953.) 4*s*. [123

Brompton Hospital Reports: a Collection of Papers recently Published from the Hospital. Vol. 21, 1952. Pp. vii+206. (London: Brompton Hospital, 1953.) 15*s*. net. [123

British Journal of Animal Behaviour: Official Journal of the Association for the Study of Animal Behaviour. (Quarterly.) Vol. 1, No. 1, January. Pp. 40. (London: Baillière, Tindall and Cox, Ltd., 1953.) Annual subscription, 27*s*. 6*d*. [173

Bulletin of the British Museum (Natural History). Zoology, Vol. 2, No. 1: The Ostracod Genus *Trachyleberis*. By J. P. Harding and P. C. Sylvester-Bradley. Pp. 16+2 plates. 4*s*. Zoology, Vol. 2, No. 2: On the Puerulus Stage of some Spiny Lobsters (*Palinuridæ*). By Isabella Gordon. Pp. 17–42. 6*s*. (London: British Museum (Natural History), 1953.) [173

## Other Countries

Gold Coast. Forestry Department Bulletin No. 4: The Vegetation Zones of the Gold Coast. By C. J. Taylor. Pp. vi+12. (Accra: Government Printer, 1952.) 2*s*. 6*d*. [53

Publications de l'Institut National pour l'Étude Agronomique du Congo Belge. Série Scientifique No. 55: Cartographie et caractérisation pédologique de la Catena de Yangambi. Par Prof. L. De Leenheer, J. D'Hoore et K. Sys. Pp. 62. 50 francs. Série Scientifique No. 56: Recherches sur la transpiration et le bilan d'eau de quelques plantes tropicale (Palmier à huile, Caféier, Cacaoyer, etc.). Par Dr. A. Ringoet. Pp. 139. 140 francs. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1952.) [103

Companhia de Diamantes de Angola. Publicacoes Culturais No. 15: Museu do Dondo; Subsidios para o estudo da biologia na Lunda. Estudos Diversos, 7. Pp. 136. (Lisboa: Companhia de Diamantes de Angola, 1952.) [103

Institut de France. Académie des Sciences Annuaire pour 1953. Pp. 248. (Paris: Libr. Gauthier-Villars, 1953.) [103

Norsk Polarinstitutt. Meddelelser Nr. 69: Norsk Ishavsfangst, en fortegnelse over litteratur. Ved Adolf Hoel. Pp. 23. 2.50 kr. Meddelelser Nr. 70: Plants collected in Vestspitsbergen in the Summer of 1933. By Asbjørn Hagen. Pp. 14. 2 kr. Meddelelser Nr. 71: Conglomerates formed in situ on the Gipshuk Coastal Plain, Vestspitsbergen. By Rolf W. Ferling-Hanssen. Pp. 9. 2.50 kr. Skrifter Nr. 97: The Downtonian and Devonian Vertebrates of Spitsbergen, 9, Morphologic and Systematic Studies of the Spitsbergen Cephalaspida: Results of Th. Vogt's Expedition 1928 and the English-Norwegian-Swedish Expedition 1939. By Gustav Wängsjö. A, Text. Pp. 615. B, Plates. Pp. 42+118 plates. 75 kr. (Oslo: Jacob Dybwad, 1952.) [103

Leybold Polarographische Berichte. Band 1, Heft 1-2, Oktober. Pp. 54. (Köln: Staufen-Verlag, 1952.) Jährlich, 10 D. marks. [103

Articulos cientificos publicadoes en America Latina. Vol. 3, 1950. Pp. viii+324. (Montevideo: Centro de Cooperacion Cientifica de la Unesco para America Latina, 1952.) [103

Bulletin of the Madras Government Museum. New Series, General Section, Vol. 3, No. 4: Indian Epigraphy and South Indian Scripts. By C. Sivaramamurti. Pp. viii+280+12 plates. (Madras: Government Press, 1952.) 14.8 rupees. [103

Universität Hamburg. Abhandlungen aus dem Gebiet der Auslandskunde, Band 57, Reihe C, Naturwissenschaften, Band 16: Regionale Typen im Jahresgang der Niederschläge in Vorderindien und ihre Beziehung zu Landschaftsgrundlagen. Von Hildegard Ludwig. Pp. ix+144. (Hamburg: Cram, de Gruyter und Co., 1953.) 21 D. marks. [103

Scientific Reports of the Indian Agricultural Research Institute for the Year ended 30th June 1950. Pp. 101. (Delhi: Manager of Publications, 1952.) 3.12 rupees; 6*s*. [103

Commonwealth Scientific and Industrial Research Organization. Bulletin No. 268: An Australian Phytochemical Survey, 2, Alkaloids in Queensland Flowering Plants. By L. J. Webb. Pp. 99. Bulletin No. 270: Rubber Accumulation in Guayule (*Parthenium argentatum* Gray) in South Australia. By R. E. Shapter. Pp. 31+8 plates. (Melbourne: Commonwealth Scientific and Industrial Research Organization, 1952.) [103

Bernice P. Bishop Museum. Bulletin 208: Report of the Director for 1951. By Charles H. Edmondson. Pp. 48. Bulletin 209: The Flora of Ponape. By Sidney F. Glassman. Pp. 152. Special Publication 42: Charles Montague Cooke, Jr., a Bio-Bibliography. By Yoshio Kondo and William J. Clench. Pp. v+56. (Honolulu: Bernice P. Bishop Museum, 1952.) [103